*Fish and Wildlife Research* 11

# Population Characteristics and Simulation: Modeling of Black Ducks



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*Fish and Wildlife Research* 11

# Population Characteristics and Simulation Modeling of Black Ducks

By Warren Wayne Blandin

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
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# Preface

The *Fish and Wildlife Research* series accepts scientific reports representing original research of scholarly quality. This series may also include interpretive literature reviews or theoretical presentations. In all respects, Warren Blandin's doctoral dissertation on American black ducks embodies the substance and spirit of these definitions. The research was scholarly, a comprehensive literature review was incorporated into the text and, in testimony to the author's intellectual drive and dedication to a search for facts and relations, the discourse includes important theory applicable to management and research needs. In the Foreword, Henry M. Reeves and James D. Nichols delineate why the thesis found immediate application in a court case, and why it continues to be a standard reference in scientific and operational realms, further attesting to Dr. Blandin's perspicacity.

Publishing a dissertation in its entirety, virtually unedited, meant breaking the precedent of our requirement that all manuscripts for this series undergo anonymous peer review. It also meant that our "house" style could not prevail in the various minutiae of hyphens, footnotes, abbreviations, citation form, and other details germane to copy editing. Warren Blandin was described as a "gifted writer" by a friend and colleague, and in my opinion the thesis needed little intrusion by an editor's pencil. In this instance Dr. Claude T. Bishop, Editor-in-Chief for the National Research Council of Canada, has an appropriate perspective: "What matters is the scientific content, and as long as that is expressed clearly in retrievable form the literary style is of lesser consequence."

After a request from the Patuxent Wildlife Research Center (PWRC) to consider publishing the dissertation, I polled 11 scientists—Blandin's colleagues who had been or are engaged in American black duck research—regarding the PWRC proposal. Respondents unanimously encouraged publication. The majority favored publishing the thesis in its entirety, unedited, to "depict his work as he saw it, and preserve the original flavor." His wife, Joan, graciously gave approval, thereby releasing this unpublished document. We here present the unabridged dissertation.

Publication is providing broad access to the thesis and allows it to be cited as formal literature. The Fish and Wildlife Service is pleased to recognize Dr. Warren W. Blandin and his definitive research.

Fort Collins, Colorado
October 1991

Curtis H. Halvorson
Wildlife Editor
Office of Information Transfer

# Foreword

Death is particularly cruel when it strikes one in the prime of life before one is given the chance to fulfill life's ambition. So it was with Dr. Warren W. Blandin, who died suddenly on 26 November 1982 at age 46, of spontaneous pneumothorax.

Only a few months before, Warren had been awarded a Ph.D. by Clark University in Worcester, Massachusetts. His dissertation, *Population Characteristics and Simulation Modelling of Black Ducks*, had been put to serious test in a suit, brought by The Humane Society of the United States and the Maine Audubon Society, against the U.S. Department of the Interior for its alleged mismanagement of the American black duck (*Anas rubripes*). Warren's findings and expert testimony—possibly subjected to even more intensive examination than by his graduate committee at Clark—were largely responsible for U.S. District Court (Washington, D.C.) Judge J. H. Green's ruling for the government. However, Warren was not to see his labor translated into a publication that would perpetuate his endeavor, nor into a management plan that would enhance the species' welfare.

Some background information on the black duck seems in order. Inexplicably, the black duck of the Atlantic seaboard was overlooked by most explorers and colonists. Early chroniclers of New France (eastern Canada), in mentioning birdlife there, ignored it completely (e.g., Lescarbot 1618; Denys 1672), or thought that the species that they did see were "like those we have in France. . ." (Le Clerq 1691). A few years later, the Sieur de Dièreville (1708:121) reported "They [wood ducks] are very different from the Common Black Duck, which is almost literally that color. . ."

Similarly, in the more southern colonies that were to compose the United States of America, the black duck was given scant early attention. John White, an associate of Sir Walter Raleigh, made drawings of 32 species he recognized in the vicinity of Roanoke Island, in what is now North Carolina (Feduccia 1985), but the black duck is not among them. In 1709 John Lawson composed the first list of American birds, totaling 129 species. In it, he mentions "Ducks black, all Summer." Apparently these were black ducks. Later, Mark Catesby, an early English naturalist in Carolina, described and illustrated 109 species of birds in his monumental *Natural History of Carolina, Florida, and the Bahama Islands. . .*(1731–1743), but the black duck is conspicuously missing. Thomas Jefferson, in his *Notes on the State of Virginia* (1787), supplemented Catesby's list of birds with 33 additional species—but not with the black duck.

Although Linnaeus (Linnaei) included eight species of ducks unique to North America in his *Systema Naturae*, 10th ed. (1758), the black duck remained elusive. Indeed, it was not until the 13th edition of *Systema Naturae* in 1789 by Linnaeus's protege Gmelin, that the black duck was given scientific legitimacy.

Whatever the reason for the black duck's unfamiliarity to many naturalists, the species was well known to many other Americans. It was table fare for early settlers, and an item commonly offered in game markets of the day. Later, many sportsmen considered it the premier sporting duck of the Atlantic Coast, from the Canadian Maritimes to the southeastern United States.

The black duck remained in a relatively abundant, apparently prosperous species into the early 20th century. With a breeding range insulated from the recurrent droughts of the prairies, it was favored by relatively stable environmental conditions. It, along with the wood duck (*Aix sponsa*) and the hooded merganser (*Lophodytes cucullatus*), were truly northern American ducks, unlike most other species, some of whose members wintered farther south. Surely it was a species that could be perpetuated and wisely managed by North Americans for North Americans.

As a teenage duck hunter during World War II years, I (Reeves) clearly recall the thousands of black ducks that traded on each autumn and winter flood tide between Delaware Bay and the wild-rice marshes of the Maurice River in southern New Jersey. In the early 1940's, many would-be duck hunters were in military service, and the activities of the remaining few were greatly curtailed by scarcity of ammunition and gasoline. Unfortunately, those bonanza years of the black duck went unrecorded because no comprehensive standardized waterfowl population surveys were being undertaken. However, it is my considered opinion that the black duck population so familiar to me during World War II was very large by today's standard—and unlikely to be equaled again. With the conclusion of hostilities, veterans by the millions turned to hunting as their preferred sport. Hunting pressure on waterfowl intensified everywhere. It, plus accelerated

habitat destruction, pollution, pesticide contamination, lead poisoning, and competition and hybridization with a burgeoning mallard (*Anas platyrhychos*) population set the stage for the deteriorating black duck population Warren was to investigate.

State and federal (United States and Canadian) wildlife agencies soon established population surveys but in the early years these were experimental in design, and it was not until the mid-1950s that comparable data became available for analysis. Waterfowl harvest surveys were initiated in 1952 in the United States, and Canada began similar harvest surveys in 1967. The banding of waterfowl, including black ducks, was begun in a coordinated manner. Waterfowl flyway councils (composed of state and provincial wildlife administrators) and flyway technical committees (composed of state and provincial waterfowl biologists) were organized in 1952, to work with federal agencies in planning, coordinating, and implementing cooperative waterfowl programs. On its part, the U.S. Fish and Wildlife Service established Flyway Representative positions in each of the four flyways.

It soon became apparent to state and federal workers that the black duck population was declining, but the reasons were not apparent. In 1968, a Black Duck Symposium was convened "for the purpose of bringing together most of the known information on this species and to focus attention to its future needs." (Barske 1968). One such need was a detailed analysis of the accumulated banding and recovery data for the black duck. The voluminous report *Black Duck Distribution, Harvest Characteristics, and Survival* (Geis et al. 1971) fulfilled that obligation.

In 1972, Atlantic Flyway Representative C. Edward Addy retired, and the Service chose Warren W. Blandin as his successor. Warren had recently completed his doctoral resident requirements at Clark University while employed as Superintendent of Wildlife Research and Management for the Massachusetts Division of Fisheries and Wildlife. He subsequently decided to undertake his dissertation study while engaged full time as Atlantic Flyway Representative, which made for a formidable task.

Early on, Warren solicited my (Reeves') views, as his supervisor, about a waterfowl species suitable for a population dynamics study. My suggestion was the blue-winged teal (*Anas discors*). This species had not been studied on a rangewide basis, was widely distributed over the eastern three-fourths of the United States and southern Canada as a breeding, migrating, or wintering bird, and it wintered far into Latin America. The species was then being hunted in special September seasons, even though conclusive biological justification for such seasons had not been demonstrated. The population dynamics of the blue-winged teal, using the available population survey, banding, and harvest information, offered a comparatively tidy research study I thought.

Courageously, and as it later evolved, wisely, Warren disregarded my suggestion. He chose instead to re-examine the tougher and more critical enigma of the declining black duck, using newer, more appropriate statistical techniques than those available to Geis et al. (1971). These statistical methods were being developed by Drs. David R. Anderson and Kenneth P. Burnham, Blandin's colleagues located at Laurel (Maryland), and Drs. Cavell Brownie and Douglas S. Robson, statisticians at Cornell University, Ithaca, New York.

Warren began his dissertation research at Laurel in the early 1970's. He relentlessly but unobtrusively pursued his task, usually after hours at the office or home, weekends as well as evenings, while still performing his primary responsibilities as Atlantic Flyway Representative in an exemplary manner.

The data–analytic methods used by Warren in his dissertation research were quite new and required substantially more background work than would have been necessary with more standard methods. His investigations dealing with the effects of exploitation on black duck survival were especially thorough, given the methods available at the time. I (Nichols) suggested to Warren that his analyses of sources of variation in survival and recovery rates were more than adequate for a good dissertation. However, his consuming interest in the species led him to seek an overall appraisal of black duck population dynamics. He accomplished this by developing population projection models that effectively synthesized his other data and estimates, and produced inferences about overall population dynamics.

The exceptional quality of *Population Characteristics. . .* was recognized immediately, and this yet-unpublished dissertation became the definitive work on black duck population dynamics. It was cited frequently in the Memorandum Opinion issued by Judge Green in response to the 1982 lawsuit. It was cited and quoted extensively in the subsequent monograph by Grandy (1983) on black duck management. Furthermore, it laid the groundwork for several subsequent analyses of black duck banding and recovery data (Conroy and Blandin 1984; Boyd and Hyslop 1985; Krementz et al. 1987, 1988; Nichols et al. 1987) and provided the impetus for a new study of winter survival (Conroy et al. 1989) and a special aerial survey (Conroy et al. 1988).

*Population Dynamics. . .* still provides some of the

best evidence bearing on questions about the effects of hunting on black duck survival (Conroy and Krementz 1986, 1990). Testimony to the continued relevance and importance of the dissertation is provided by its extensive citation in the recent report of The Wildlife Society's Ad Hoc Technical Advisory Committee on Black Duck Conservation and Management (Rusch et al. 1989).

The historical importance of Warren Blandin's dissertation and its continued relevance to questions about black duck population dynamics have led to the Service's decision to ensure its perpetual availability to interested scientists and managers through publication. Warren had told us of his hopes to publish *Population Characteristics. . .* in the Fish and Wildlife Service Resource Publication series, believing that some refinement and rewriting would first be necessary. He had intended to begin this work as soon as the 1982 lawsuit was settled—but death intervened.

Initial considerations about publication included the possibility of attempting to refine the manuscript, as Warren had envisioned. It was concluded, however, that any revision by others, no matter how minor, would pose the risk of changing Warren's "message" and altering the presentation of his well-founded and expressed ideas about black duck population dynamics. Therefore, it was decided to publish *Population Characteristics and Simulation Modeling of Black Ducks* in a form as close to the original as a different format permits. Although this publication does not benefit from any refinement or rewriting by Warren, it is still of high quality and reflects Warren's high professional standards. It is a landmark study, and we believe that it will continue to be an important basic reference on the population ecology of the species for many black duck migrations to come.

In concluding, we would be greatly remiss not to say something of Warren's character and personality (also, see Brakhage 1983). He had many sterling attributes beyond those of intelligence and dedication, both so obvious to his many acquaintances. Gentlemanly and considerate at all times, he listened to and often accepted divergent viewpoints if they would further waterfowl management. Innovative and resourceful, he devised or promoted workable solutions to difficult problems. Warren's wit and tact eased occasional strained situations. He was greatly respected and liked by his peers—perhaps the highest acclamation a professional can earn. Quietly religious, he was the epitome of the family man. The shock of his early death on his loving wife, Joan, his daughters, Pamela and Kristen, and his son, Jonathan, cannot be envisioned. They had given Warren unmeasured support as he pursued the most comprehensive study of the black duck yet then undertaken.

We are gratified that the U.S. Fish and Wildlife Service has chosen to publish Dr. Blandin's dissertation in its entirety. This decision, although belated, fills an important void in the information chain for the still-beleaguered black duck and makes public and perpetuates the efforts of one who worked tirelessly on its behalf.

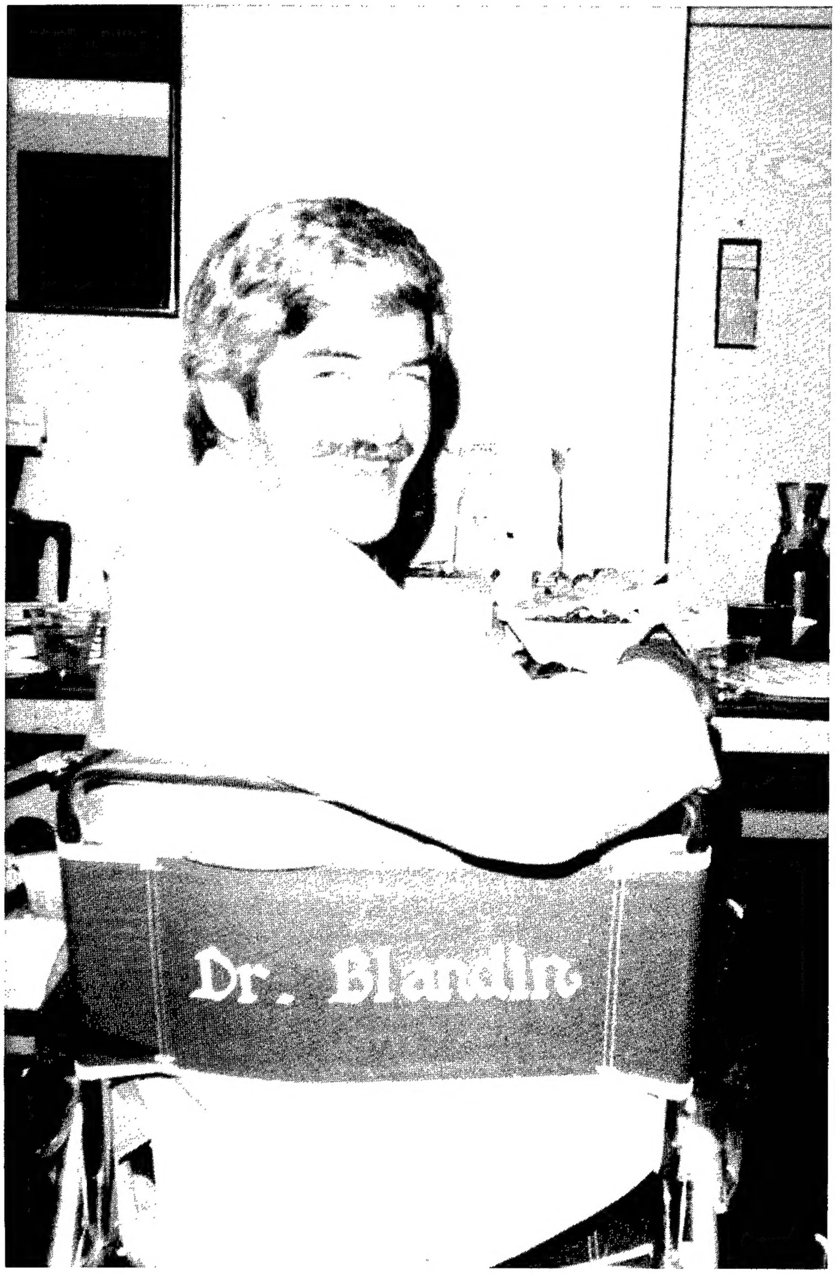
Amity, Oregon

Henry M. Reeves
U.S. Fish and Wildlife Service
*retired*

Patuxent, Maryland

James D. Nichols
U.S. Fish and Wildlife Service

May 1991




Warren Wayne Blandin, 1936–1982.

TITLE

# POPULATION CHARACTERISTICS AND SIMULATION MODELLING OF BLACK DUCKS

AUTHOR'S NAME

Warren Wayne Blandin

ABSTRACT OF A DISSERTATION

submitted to the Faculty of Clark University, Worcester, Massachusetts, in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Department of Biology

Abstract approved for publication

Rudolph F. Nunnemacher

CHIEF INSTRUCTOR

Professor Rudolph F. Nunnemacher

# Abstract

This study was initiated because of concern for the population status of black ducks, and because excessive black duck harvest has been implicated in the decline of the black duck population as evidenced by Winter Survey trends. A review of literature about black duck distribution, migration, and population dynamics is presented. The preseason and winter banding and recovery files are described and their limitations are discussed. Twenty-seven preseason major reference areas of banding and 15 winter major reference areas of banding are defined.

Survival and recovery estimates are derived using methods described by Brownie et al. (1978). Recovery rates from preseason and winter banding periods for all age–sex groups vary by geographic area and year. Survival rates are less variable but differences are detected in several geographic areas. Adult survival rates are similar for the preseason and winter banding periods. Adults survive at a significantly higher rate than young, and adult males survive at a higher rate than adult females. The annual survival rate averaged over years and across geographic areas is estimated to be 63% and 56% for adult males and females, respectively, and 43% for young males and females. Annual estimates of recovery rates and survival rates and their sampling variances are shown for each age and sex group for preseason and winter bandings in 6 appendixes.

Hunting mortality is estimated to be 57% of adult male total mortality based on preseason bandings. Comparable estimates for adult females, young males, and young females are 47%, 65%, and 63%, respectively. Survival rates in years of liberal hunting regulations are similar to survival rates in years of restrictive regulations. This supports the idea that hunting mortality is largely compensated for by a reciprocal response in natural mortality. However, a correlation analysis of the preseason recovery rate to the ratio of early winter: late winter recovery rates failed to detect evidence of compensatory mortality on the wintering grounds following hunting seasons with high harvest rates. Correlation analyses showed a significant positive correlation between adult male recovery rates (winter bandings) and season length, and a significant negative correlation between adult male recovery rates and survival rates. This implies that long seasons may be detrimental to the survival of adult males. Despite the findings relative to restrictive versus liberal regulations, the harvest of black ducks, especially of young birds, may have been, or is, excessive in local areas, particularly on the breeding grounds. This conclusion is based on circumstantial evidence, primarily the low survival of young black ducks, the high proportion of the total mortality of all age–sex groups attributable to hunting, and the relationship of season length to survival rate in adult males. Despite good annual production, insufficient recruitment of young to the breeding population may be limiting population growth.

Deterministic and stochastic models are used to evaluate population estimates. The population sex ratio is estimated to be 1.20 to 1.38 males per female. The effects of small changes in parameter values are explored. Corrections for positive bias in the survival and production estimates are required to produce a Continental Black Duck Population trajectory that tracks the population curve derived from Winter Survey data.

Management recommendations are presented relative to hunting regulations and to banding programs. Research needs are described with emphasis on improving the design of various operational surveys.

TITLE

# POPULATION CHARACTERISTICS AND SIMULATION MODELLING OF BLACK DUCKS

AUTHOR'S NAME

Warren Wayne Blandin

A DISSERTATION

submitted to the Faculty of Clark University, Worcester, Massachusetts, in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Department of Biology

and accepted on the recommendation of

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RESEARCH PAPERS, THESIS or DISSERTATION PRÉCIS

DEGREE PH.D

DEPARTMENT BIOLOGY

TITLE OF RESEARCH PAPERS, THESIS, OR DISSERTATION

POPULATION CHARACTERISTICS AND SIMULATION MODELLING OF BLACK DUCKS

AUTHOR'S NAME (Mr.; ~~Mrs.~~; ~~Miss~~) Warren Wayne Blandin

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|---|---|
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PRÉCIS
(75 words)

Black duck population parameters are estimated using data from the U.S. Fish and Wildlife Service banding and recovery files and Waterfowl Harvest Surveys. Statistical tests are used to determine differences in survival and band recovery rates between age-sex groups, geographic areas and over time. The effect of harvest on population survival is tested statistically, and the proportion of total mortality attributable to hunting mortality is estimated. Parameter estimates are used in deterministic and stochastic modelling experiments to validate various survey parameter estimates and to evaluate the effects of small changes in parameters. Management recommendations are presented and research needs are discussed.

# Conclusions

At the time, Blandin (1982) constituted the best basis for management decisions directed toward maintaining or improving the population status of American black ducks. Warren's thesis was a solid piece of synthetic research that provided a good understanding, within the limits of available data, of the population ecology of this species. Warren's understanding of the important "big picture" questions about black ducks also provided anticipation of and motivation for critical research topics in the decade to follow. To the extent that we understand how black duck populations behave, and how they should be managed, we owe a tremendous debt to Warren Blandin.

# Acknowledgements

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# Part I.

## Introduction

This study is designed to investigate the population dynamics of black ducks (*Anas rubripes*), particularly as they relate to harvest, to provide information of management importance, and to identify research needs. The black duck traditionally had been the most numerous species in the Atlantic Flyway waterfowl harvest, but in 1969 it was surpassed by the mallard (*Anas platyrhynchos*), and in 1971 by the wood duck (*Aix sponsa*). However, the black duck's population status has been a concern of eastern waterfowl biologists since the early 1960's when Winter Survey data indicated a downward trend in numbers. Symposia related to black duck population ecology and management were held at Remington Farms, Chestertown, Maryland, in 1969 and at Moncton, New Brunswick, in 1973; both symposia were initiated by the Atlantic Flyway Council.

An intensive study of black duck banding data for the period 1946 through 1960 by the U.S. Fish and Wildlife Service's Migratory Bird Populations Station (Geis et al. 1971) implicated black duck harvest as a significant factor restricting population growth. Since 1960 the number of waterfowl hunters has doubled, and although some restrictive regulations have been implemented, the black duck harvest has remained fairly stable despite a continued downward trend in the Winter Survey estimates for black ducks. Continued concern about the effect of hunting on the black duck population, and the development of sophisticated statistical methodology to measure and compare various population parameters, prompted this second comprehensive study of the black duck.

The study objectives are:

1. To determine the role of hunting and hunting regulations in the management of the black duck (vulnerability associated with age, sex, time periods, and harvest areas) and the effect of hunting mortality on total mortality.
2. To measure survival rates of black duck populations in various states and provinces, and major and minor reference areas, and to determine the proportion of total mortality caused by hunting.
3. To determine production rates and compare these rates with mortality rates to evaluate the status of various populations.
4. To employ empirical data in simulation models and related experiments to evaluate the performance of survey and band recovery data in the simulation models, and to evaluate the effects of changes in various population parameters on the simulated population.
5. To make management recommendations and identify research needs.

Several hypotheses related to temporal and geographic differences in recovery rates and survival rates and to differences in these rates between various age–sex groups are tested. In addition, the hypothesis that survival rates in years of liberal regulations are the same as survival rates in years of restrictive regulations and the hypothesis that the survival rate of preseason banded birds is the same as the survival rate of winter banded birds are tested.

The principal source of data used for this study was the black duck banding files located at the Bird Banding Laboratory, Office of Migratory Bird Management, Laurel, Maryland. The banding data are described under "Sources of Data" below. Ancillary data sources used were (1) the annual Waterfowl Harvest Surveys (Martin and Carney 1977), which include the Hunter Questionnaire Survey and the Duck Wing Collection Survey, and (2) the annual Mid-Winter Waterfowl Survey (hereafter called Winter Survey), which provides population trend information for many waterfowl species. Data from this survey are produced by the Office of Migratory Bird Management and appear as a series of four annual flyway reports: Atlantic, Mississippi, Central, and Pacific.

# Review of Past Work

## *Distribution*

The black duck has been recorded as an abundant species in maritime Canada and Quebec since the late 1990's when the first accurate historical records were documented (Boardman 1903; Chamberlain 1882, 1887; Chapman 1901; Dionne 1906; Downs 1887; Macoun and Macoun 1909). The species' historical distribution in Ontario is less certain. Phillips and Lincoln (1930) indicated that southeastern Ontario has always had the largest breeding populations. Black duck numbers in northern Ontario are lower and more sparsely distributed. Alison (1977) noted that forested habitats in southwestern Ontario provide only limited breeding habitats for black ducks, and that this condition has persisted until recently.

Manitoba and the Northwest Territories represent the western limits of the black duck range. Numbers fluctuate greatly from year to year in the region (Taverner 1934; Phillips 1923; Kortright 1942). Although Taverner (1934) recorded the black duck as a breeding species in Manitoba and along the west coast of Hudson Bay, Palmer (1976) believed the species' breeding range a century ago did not extend westward much beyond Lake Erie and central Ontario. He stated that the black duck has extended

its range westward into Minnesota and western Ontario at a time when its overall numbers were declining in its traditional range. The accounts of Cooke (1906) and Phillips (1923) agree with Palmer's concerning the absence of breeding black ducks west of the Great Lakes early in this century. More recently, Palmer (1976) noted that the mallard has succeeded the black duck as a nesting species in the Hudson Bay lowlands. Cringan (1960) reviewed the relative change in numbers and distribution of black ducks and mallards in Ontario, and concluded that the mallard has increased greatly in southern Ontario. Alison (1977) reviewed historical accounts of Ontario black ducks and concluded that the species is as abundant as ever, and that perhaps its status in the region has not changed significantly since the 1500's. However, recent breeding grounds surveys in Ontario (Collins 1974) suggest a significant reduction in breeding black duck numbers in those portions of Ontario bordering on the Great Lakes.

Forbush (1925), Aldous and Mendall (1940), and Griscom and Snyder (1955) noted the historical abundance of the black duck in the northeast, where the species is a common breeder, migrant, and wintering bird. Stewart (1958), in a comprehensive review of available data, described the hemlock–white pine–northern hardwood forest east of 85°W longitude, and the tidewater areas of Delaware Bay and the eastern shore of Chesapeake Bay, Maryland, as the two general habitat types with high black duck breeding populations. He found boreal coniferous forests and northern tidewater areas intermediate in breeding population densities, whereas tidewater and forested areas south of Chesapeake Bay to Cape Hatteras, North Carolina, support low breeding population densities. Stewart's black duck distribution maps are presented in Figures 1a and 1b. The black duck's propensity for forest habitats, even in tidewater areas, was demonstrated by Stotts and Davis (1960) who noted that 60% of 731 nests located in the Chesapeake Bay area, Maryland, were in wooded habitats, and only 17% were in marshes.

Phillips (1923:69–70) listed probable or confirmed breeding records for all the Great Lakes states except Minnesota; however, Roberts (1932:228–230) listed the black duck as a breeding bird in northern Minnesota since the 1930's. He considered the black duck breeding population in the state to be of recent origin. Barrows (1912:79) listed the black duck as breeding sparingly in northern Michigan, whereas Pirnie (1935:11) indicated that the black duck was greatly outnumbered by the mallard in the late 1900's, but currently (1930's) was the most plentiful resident duck.

Kumlien et al. (1951:12) listed the black duck as a breeding bird in Wisconsin within historical times, but the species represents only 1% of current waterfowl breeding populations in Wisconsin (March et al. 1973:9). Bellrose (1964) indicated that black ducks never were abundant breeders in Indiana. Earlier, Butler (1897:598) stated that there were no breeding records of black ducks in Indiana, whereas Wheaton (*in* Dawson 1903:585) believed that black ducks formerly bred in Ohio.

Wintering black duck populations in Canada are most numerous in Nova Scotia and Prince Edward Island where about 23,000 winter each year (Stewart 1958). Alison (1977) reported that black ducks have remained to winter in Ontario only since the 1930's. Slightly more than 1,000 birds are observed each year in the Toronto area. Stewart (1958) estimated that 10% of the total continental black duck wintering population could be found in the northern New England–Maritime Canada–Great Lakes region, whereas 61% wintered on the Atlantic Coast from Massachusetts to North Carolina. One-fifth of the wintering population is located in the east-central states (Tennessee, Kentucky, Ohio, Indiana, Illinois) and one-tenth in the southeastern states. Phillips (1923:72) identified the black duck as a winter resident along the Gulf Coast of Alabama, Mississippi, Louisiana, and Texas. Later writers have confirmed Phillips' data (Burleigh 1944:352; Lowery 1974:182; Oberholser 1974:157; Imhof 1976:102). Johnsgard (1961) reviewed the winter distribution of black ducks and mallards in the eastern United States by comparing the periods of 1940–1949 and 1950-1959. He noted that the mallard has expanded its range in nearly every eastern state whereas the black duck has increased its numbers in only two states (Minnesota and Wisconsin). Johnsgard found that "pure" black duck populations existed only in Maine and the Canadian Maritimes. Johnsgard and DiSilvestro (1976) reviewed Winter Survey ratios of black ducks to mallards for the period 1900 to 1975. Relative to mallard numbers, an apparent black duck decrease was noted throughout his range. The authors concluded that the mallard has replaced the black duck as the dominant wintering species in the east. Habitat changes, mallard stocking, hunting regulations, and climatic trends were suggested as possible causes for the dramatic change in the relative abundance of the two species.

## *Migration*

H. S. Osler banded black ducks on Lake Scugog in south-central Ontario throughout the 1920's. Results from his efforts were reported by Lincoln (1924, 1927). A

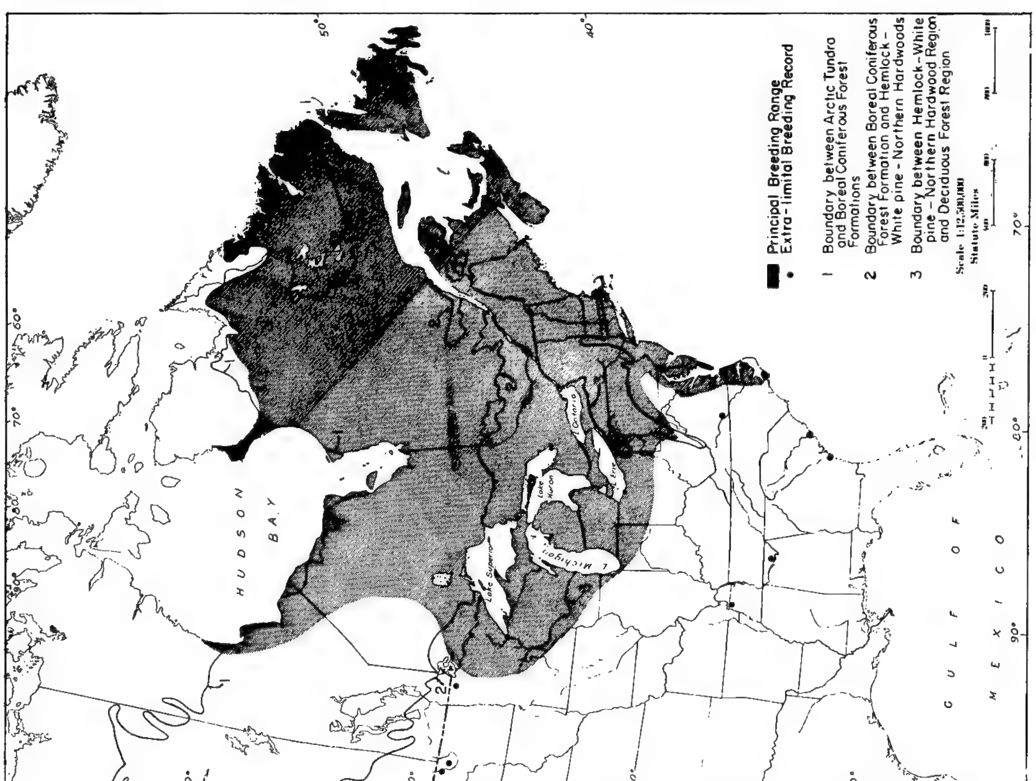



**Figure 1a.** Breeding range of the black duck (*Anas rubripes*).

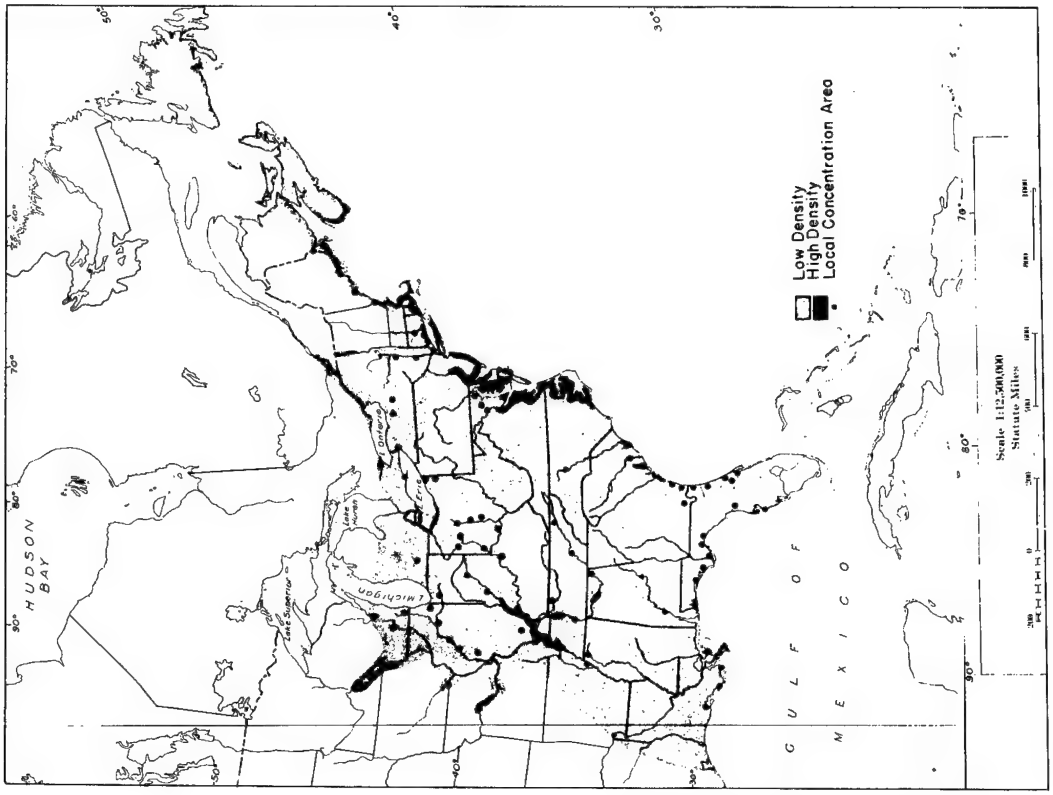



**Figure 1b.** Principal wintering range of the black duck (*Anas rubripes*).

rather broad dispersal of black ducks into almost every state east of the Mississippi River was noted and nearly equal numbers of black ducks were recovered in the Mississippi and Atlantic Flyways.

Pirnie (1932) described the migration of black ducks from northern Michigan. His results differed from the Lake Scugog bandings. A greater proportion of the recoveries were in the Mississippi Flyway. Pirnie's data also showed that black ducks banded in association with each other do not necessarily migrate together. Martinson and Hawkins (1968) demonstrated the same behavior with respect to brood mates. Hagar (1946a, 1946b, 1951) provided detailed accounts of bandings on Cape Cod, Massachusetts, and at Newburyport, Massachusetts. On the basis of his findings he proposed a Northeastern Flyway (Hagar 1954) having a distinct subpopulation of wintering black ducks which would be managed independently of other black ducks in the Atlantic Flyway.

Addy (1953) described regional subdivisions of black ducks based on band recovery distributions. His findings, which resulted from the analysis of considerably more banding data than was available to Hagar, suggested that northeastern black ducks were found in New Jersey and other mid-Atlantic states to a greater degree than realized previously. However, Addy did recognize "sedentary" populations of black ducks in several northern areas. In an appendix, Addy provides an excellent synopsis of black duck banding programs up to the early 1950's.

Lemieux and Moisan (1959) analyzed bandings from four stations in eastern and southern Quebec. They recognized two distinct populations based on differences in distribution, recovery rates, and mortality rates. Black ducks from southern Quebec had lower survival rates than black ducks in eastern Quebec on the north shore of the St. Lawrence River.

Bellrose (1968) employed radar observations, aerial and ground observations, and various surveys and inventories to describe "flight corridors" representing waterfowl movements of varying size and direction. Bellrose and Crompton (1970) refined the "flight corridor" technique in their study of mallard and black duck migrational behavior by including mean axial lines of longitudinal distribution and by examining the latitudinal distribution of band recoveries as well. They concluded that black ducks showed strong homing tendencies to their traditional migration and wintering habitats.

The most thorough recent analysis of black duck banding data is that of Geis et al. (1971). The authors analyzed recovery data up to 1960 from all banding periods (Spring, Preseason, Inseason, Winter), defined reference areas for preseason and winter bandings, and described the general distribution and recovery characteristics of black ducks from each reference area.

## *Population Dynamics*

Munro (1968) reviewed the literature on black duck population dynamics including unpublished reports and file data from many state and federal conservation agencies. Intensive field studies of local black duck populations were completed by Stotts and Davis (1960) on the Chesapeake Bay, Maryland; by Reed (1975) on the St. Lawrence River, Quebec; by Coulter and Miller (1968) in Maine and on islands in Lake Champlain; by Laperle (1974) on islands in the St. Lawrence River near Montreal; and by Wright (1954) in New Brunswick. Bartlett (1963) reviewed the population status of the species on Prince Edward Island, and Boyer (1956) discussed the black duck's status throughout the Maritime provinces. Breeding grounds survey methods were tested by Kaczynski and Chamberlain (1968) in eastern Canada south and east of James Bay. They concluded that surveys similar to those conducted on the prairie provinces were not feasible in boreal habitats. Stirrett (1954) and Dennis (1974) studied breeding population size and distribution in southern Ontario. Dennis related his results to those of Stirrett and noted a substantial eastward expansion of mallard breeding populations.

Estimates of black duck fall flight population size were provided by Geis et al. (1971) for the 1950's (3.7 million), by Martinson et al. (1968, 1.9 million) for the period 1961–1968, and by Pospahala et al. (1971) for the period 1967–1970. The estimate of 2.7 million by Pospahala et al. (1971) based on harvest and band recovery data is similar to the population estimate derived in this study (2.8 million) using the same methods, but for the period 1971–1976. Recent estimates by Canadian Wildlife Service biologists based on productivity values related to various habitat types produced a population estimate of 2.4 to 2.9 million black ducks depending on certain model assumptions. This suggests a relatively stable black duck population over the period 1967–1980.

## *Mortality*

Bellrose and Chase (1950) provided the first published estimates of black duck mortality. Their analysis was based on bandings during the hunting season at McGinnis Slough, Illinois, over the period 1940–1945, but included band recoveries up to 1, January 1948. Their composite dynamic life table estimate (Deevey 1947) of average black duck mortality, all age–sex groups

combined, was 53.7%. Correction factors were developed to account for birds shot during the hunting season prior to banding. Wright (1954:105–107) developed a life equation for black ducks based on field studies and hunting losses. He estimated an overall annual mortality rate of 60%, and attributed 17.3% of all losses to winter mortality. Lemieux and Moisan (1959) calculated mean annual mortality rates for adult and young black ducks from southern Quebec and from the "North Shore" of eastern Quebec (Baie Johan Beetz). They found that both age classes of eastern Quebec populations apparently survived at a higher rate than southern Quebec birds. The absence of local direct recoveries (indicative of low hunting pressure) and greater initial dispersion of the population prior to hunting were suggested as possible explanations. Lemieux and Moisan recalculated the data of Bellrose and Chase (1950) to weight the annual mortality estimates as described by Hickey (1952) and Farner (1955). They found that the overall mortality rate of McGinnis Slough birds (49.5%) was lower than their overall mortality estimate of 52.6% for Baie Johan Beetz birds. Geis et al. (1971) provide the most comprehensive analysis of black duck banding data. They used the composite dynamic life table method also, and reported mortality estimates by the same reference areas of banding used in this study. Their results are reported in a series of tables (Tables 52–60) that relate to various banding periods, age and sex classes, and harvest regulations. Data from the preseason banding period 1946–1960 produced an average first-year mortality rate in young black ducks of 65%. Winter banding data for the same period showed that adult males had an average annual mortality rate of 38%, whereas adult females had a 47% average annual mortality rate. Generally, adult females had average annual mortality rates about one-fifth greater than adult males. Martinson et al. (1968) reviewed and updated the data of Geis et al. (1971) and derived similar results.

# Methods

## *Definition of Terms*

The following terms used in this report are defined in reference to the preseason and winter banding periods and generally follow those definitions used in the *Resource Publication* series "Population Ecology of the Mallard," U.S.D.I., Fish and Wildlife Service:

### Age

The expertise of banders, techniques for age determination, and the manner of recording age have varied over the years; consequently some caution must be used in interpreting age data. The following terms have been used to indicate ages of birds at the time of banding:

*Juvenile*. Before 1949, young were classified as juveniles. For example, a bird hatched during the 1943 breeding season and trapped and banded in August 1943 would be aged as a juvenile (regardless of its flight capability). From 1949 through 1961 the age designation "juvenile" was gradually replaced by "local" and "immature."

*Local*. A young bird-of-the-year not capable of sustained flight at the time of banding.

*Immature*. A young bird-of-the-year capable of sustained flight at the time of banding. Nearly 80% of the black ducks banded as young in this study were in this category.

*Young*. A combination of juvenile, local, and immature birds. The term "young" is taken as young birds-of-the-year, regardless of their flight capability.

*Adult*. A sexually mature bird in its second calendar year of life or later; a bird hatched during some previous breeding season. All birds banded during the Winter (banding) Period (1 January–28 February) are classified as adults.

Local bandings of black ducks were extremely limited and no statistical analyses have been performed using the "local" age data. In this study all birds-of-the-year were pooled and called "young," except in a few instances when "immature" is used as a synonym for "young" as defined (e.g., immature/adult age ratio).

### Band Recoveries

Bands reported to the Bird Banding Laboratory from banded birds are considered to be recoveries. Only band recoveries from normal, wild birds banded during the preseason or winter banding periods and reported to the Bird Banding Laboratory as "shot" or "found dead" during the hunting season (1 September through 15 February inclusive) were used in this study. These include about 95% of all preseason and winter banding recoveries (see Table 1).

### Band Reporting Rate ($\delta$)

The proportion of banded birds that is recovered and reported to the Bird Banding Laboratory; usually expressed as a percent. For example, if 1,000 banded birds are recovered by hunters and only 500 are reported, the band reporting rate ($\delta$) is 500/1,000 = 0.50 or 50%. Henny and Burnham (1976) developed regional estimates of mallard band reporting rates based on a reward band study. A black duck reward band study now in progress

Table 1. *Summary of "How Obtained" for recoveries of normal, wild black ducks from all banding periods, 1918–1976 (data are subdivided into the location where recovered).*

| How obtained | Canada | | Pacific Flyway | | Central Flyway | | Mississippi Flyway | | Atlantic Flyway | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Number | Percent | Number | Percent | Number | Percent | Number | Percent | Number | Percent |
| Shot | 17,589 | 94.46 | 22 | 91.67 | 76 | 91.57 | 18,615 | 93.24 | 45,694 | 91.35 |
| Found dead | 355 | 1.91 | | | | | 453 | 2.27 | 1,560 | 3.12 |
| Trapped or snared | 188 | 1.01 | | | 2 | 2.41 | 399 | 2.00 | 1,086 | 2.17 |
| Struck (by or into object) | 24 | .13 | | | | | 24 | .12 | 61 | .12 |
| Disease | 6 | .03 | | | 1 | 1.20 | 21 | .11 | 135 | .27 |
| Collected specimen | 14 | .08 | 1 | 4.17 | | | 4 | .02 | 7 | .01 |
| Banding mortality | 69 | .37 | | | | | 73 | .37 | 235 | .47 |
| Band found with skelton | 15 | .08 | | | 1 | 1.20 | 12 | .06 | 39 | .08 |
| Other | 360 | 1.93 | 1 | 4.17 | 3 | 3.61 | 364 | 1.82 | 1,205 | 2.41 |
| **Totals** | 18,620 | 100.00 | 24 | 100.01 | 83 | 99.99 | 19,965 | 100.01 | 50,022 | 100.00 |

has provided preliminary black duck band reporting rates which are used in this study.

### Direct Recovery

A bird recovered during the first hunting season after banding. Direct recoveries are coded HSS-1 (HSS = Hunting Season Shot). Geis (1972a) stipulates that a direct recovery is a recovery that occurs before a change of movement due to migration. This implies that all recoveries of winter banded birds are indirect recoveries since migration to, and in some cases, from the breeding grounds occurs before the hunting season. Frequently, some are referred to as "first hunting season after banding" recoveries. In this report, first hunting season recoveries of winter banded birds are called direct recoveries.

### Harvest

Retrieved or "bagged" hunting kill.

### Harvest Areas

Areas in which ducks are killed. In this study states, provinces, major reference areas, and minor reference areas are used to represent harvest areas.

### Harvest Rate (H)

The proportion of the population alive in the fall of year i that is harvested in year i. For example, if 1,000 birds are harvested from a fall population of 5,000 birds, the harvest rate is 0.20 or 20%. The band recovery rate (f; see page 00) divided by the band reporting rate ($\delta$) equals the harvest rate (H) or $H = f/\delta$, therefore, given estimates of $\delta$ and f, the harvest rate H can be estimated.

### Hunter Performance Surveys

The observation of hunters in the field, usually without their knowledge, to obtain data for comparison with Mail Survey responses, and to evaluate hunter behavior with respect to hunting regulations. Martin and Carney (1977:13) provide details about the survey procedures.

### Hunting Season

The period 1 September through 15 February, inclusive, defines the hunting season in this study. Within this period, waterfowl hunting seasons vary from place to place and from year to year. Hunting seasons in the Canadian Provinces normally open in early-to-mid-September, whereas states in the northern United States open their hunting seasons in early-to-mid-October. Southern states frequently delay the opening of their waterfowl hunting seasons until mid-November or early December.

### Indirect Recovery

A bird recovered in any hunting season following

the first hunting season after banding. Indirect recoveries are coded by the year of recovery, i.e., HSS2-N (HSS = Hunting Season Shot); hence a bird banded in July 1972 and recovered in December 1975 would be coded HSS-4, since it was recovered in the fourth hunting season after banding.

**Kill**

The total hunting kill including retrieved birds (harvest) and those lost as cripples.

**Kill Rate (K)**

The proportion of the population alive at the start of year i (1 September) that dies due to hunting (including unretrieved kill) in year i. The kill rate includes both retrieved and unretrieved kill and is synonymous with the hunting mortality rate.

**Mail Surveys**

Two waterfowl harvest surveys conducted in the United States by the Fish and Wildlife Service and in Canada by the Canadian Wildlife Service are used in this study. The corresponding surveys are the Hunter Questionnaire Survey and the Duck Wing Collection Survey in the United States, and the National Harvest Survey and the Species Composition Survey in Canada. The United States surveys are described by Martin and Carney (1977:10–12), and the Canadian surveys are described by Cooch et al. (1978:12–15).

**Mean Life Span (MLS)**

The MLS is the expected longevity of individuals when they enter the banded population under consideration. The MLS for adults is computed as $\frac{1}{-\ln \hat{S}_A}$, where $\hat{S}_A$ is the average annual survival of adults. This descriptive statistic assumes that the average survival estimate used in the computation is constant in the remaining years of life.

**Mortality Rate (M)**

The proportion of the population alive at the start of the year (1 September) that dies during the year. Mortality rate is the complement of survival rate (S), therefore $M = 1 - S$, and represents the sum of hunting (K) and nonhunting (V) mortality rates: $M = K + V = 1 - S$.

**Nonhunting Mortality Rate (V)**

The fraction of the population dying from causes other than hunting.

**Normal**

A wild bird, apparently in good health, which has been captured, marked only with a standard leg band, and immediately released at the location where it was captured.

**Preseason (Banding) Period**

The period defined as 1 July through 30 September, inclusive. It relates to the late summer–early fall prehunting season population. Generally, banding operations in a given area are terminated 7 to 10 days prior to the opening of the hunting season.

**Production Rate (P)**

The number of flying young per adult in the fall population (on 1 September).

**Recovery Rate (f)**

The probability that a banded bird will be legally shot or found dead during the hunting season and reported to the Bird Banding Laboratory in year i, given that it is alive at the time of banding in year i. The recovery rate of preseason banded birds is used as an index to hunting pressure. If the band reporting rate were 100%, then the preseason recovery rate f would equal the harvest rate H. Estimates of recovery rates are based on all the relevant data and are more efficient than the direct recovery rate, which only uses the 1st-year recoveries from birds banded in year i. The recovery rate for preseason banded birds is a product of the harvest and the band reporting rates. Normally, individual terms in the product are not estimable unless reward bands are used. Recovery rates for winter banded birds represent the product of harvest rate, band reporting rate, and the winter-to-fall survival rate.

**Reference Areas**

Geographic areas used in summarizing data are called reference areas. Banding stations located in the same general area and exhibiting similar recovery distribution patterns were combined and designated as "major reference areas" to summarize and facilitate banding and recovery data analysis. Characteristics of the breeding population were summarized on the basis of preseason reference areas. Therefore, preseason reference areas are useful in analyzing the characteristics of both the breeding population consisting entirely of adults and the preseason population composed of adults and young. Minor reference areas correspond to those portions of a state or province found within a major reference area. In this study preseason bandings are grouped into 27 major refer-

ence areas and 73 minor reference areas. Winter bandings are grouped into 15 major reference areas and 63 minor reference areas. The names of major reference areas are followed by a two-digit code number, e.g., Western Lake Erie(16). Minor reference area names are followed by a three-digit code number, e.g., Michigan(161).

The reader should study Figures 2 and 3 and Tables 6 and 7 for preseason and winter bandings, respectively, to ensure an understanding of the geographic composition of the major reference areas.

**Relative Recovery Rate**

The extent to which the recovery rate for one age, sex, or population exceeds that of another. It is most useful to express the relative differences in the likelihood of two age or sex class categories of being shot (differential vulnerability). For example, if young birds have a 1st-year recovery rate of 10% and adults have a 1st-year recovery rate of 5%, the relative recovery rate would be 10/5 = 2, indicating that young birds are twice as likely to be recovered as adults. An equal mortality rate between the time of banding and the start of the hunting season and an equal reporting rate must be assumed for the two banded samples being compared if one wishes to draw inferences about differential probabilities of being shot.

**Sex Ratio**

The preseason (1 September) ratio of adult and young males per adult and young females. The sex ratio of young was assumed to be even (1:1).

**Survival Rate**

The probability of survival of a (banded) bird during year i, given that it was alive at the time of banding in year i. Estimates of survival of the population relate to the time of banding in year i to the time of banding in year i + 1.

**Who Reported Code**

Usually, band recoveries are reported to the Bird Banding Laboratory directly by the hunter or indirectly through one of the Mail Surveys. Sometimes they are reported for the hunter by federal, state, and private conservation agency employees, hunting club managers, or others. To allow study of the influences of these sources of reports on various analysis procedures, a series of the "Who Reported" codes was established in 1957 (USDI and DE 1976; Figures 5–11).

**Why Reported Code**

Categories designating what prompted an individual to report a band. This code has been in use since September 1965 and permits identification of bands reported due to band collecting activities (USDI and DE 1976; Figures 5–12).

**Winter (Banding) Period**

Arbitrarily defined as 1 January to 28 February. This period relates to the wintering population. Although hunting does occur in most southern states early in the period, no banding is done during open hunting seasons. Banding is continued until 15 March to a limited degree in many states. March data were used for certain tests explained later, but because of the general northward movement of wintering populations in March, these bandings were not included in most banding data analyses.

## *Sources of Data*

The banding and recovery files at the Bird Banding Laboratory, U.S. Fish and Wildlife Service [USFWS], Laurel, Maryland, were the primary data sources used in this study. Secondary data sources were the Hunter Questionnaire Surveys, Duck Wing Collection Surveys, and Hunter Performance Surveys on computer files of the Office of Migratory Bird Management, and the corresponding data sources available from the Canadian Wildlife Service.

Table 1 provides a "How Obtained" summary of all black duck band recoveries from all banding periods (Spring, Preseason, In-Season, Winter) for the period 1918 through 1976. A total of 103,440 band recoveries (to and including 1977) was available for this study from 632,000 bandings. However, only data for normal, wild birds shot or found dead during the hunting season that had been banded during the preseason and winter banding periods were usable. Because of this restriction only 47,254 recoveries (45.6% of the total recoveries shown in Table 1) were used. Table 2, column 2 shows the span of years covered by banding operations in each state and province, and in parentheses, the total years of banding.

Only 2% of the preseason bandings was accomplished prior to 1945; 29% occurred in the period 1945–1960; and 69% was done in the period 1961–1978. Three percent of the winter bandings was accomplished prior to 1945, 16% was done between 1945 and 1960 inclusive, and 81% was done from 1961 through 1978. Geis et al. (1971:4) worked primarily with the 1945–1960 banding data. However, they analyzed band recoveries from Spring bandings and In-Season (Hunting Season) bandings in addition to Preseason and Winter bandings. Their initial data file totaled nearly 264,000 bandings.

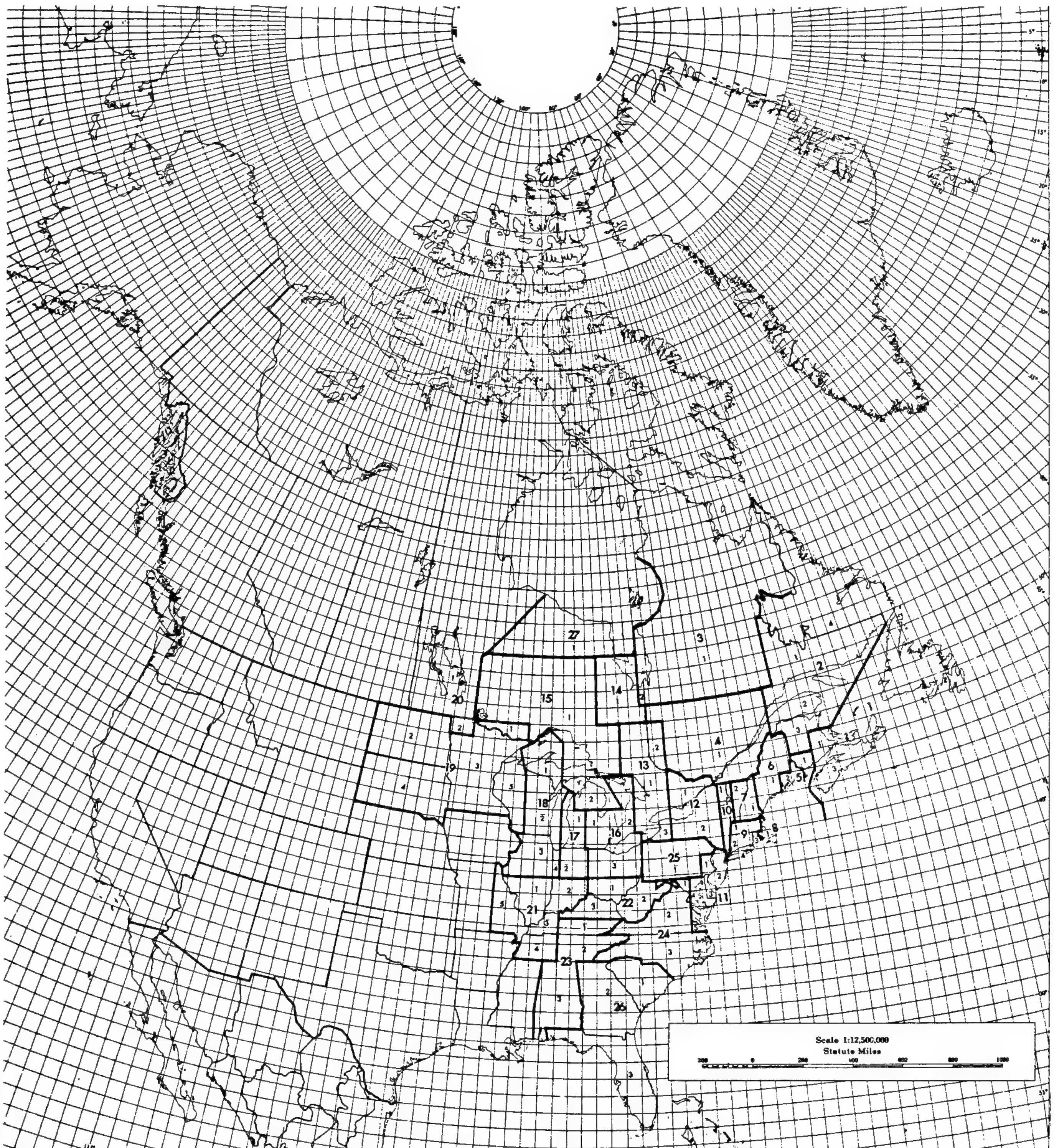



**Figure 2.** Banding reference areas representing the breeding and preseason black duck population. The large numbers relate to major reference areas; the smaller numbers relate to minor reference areas.

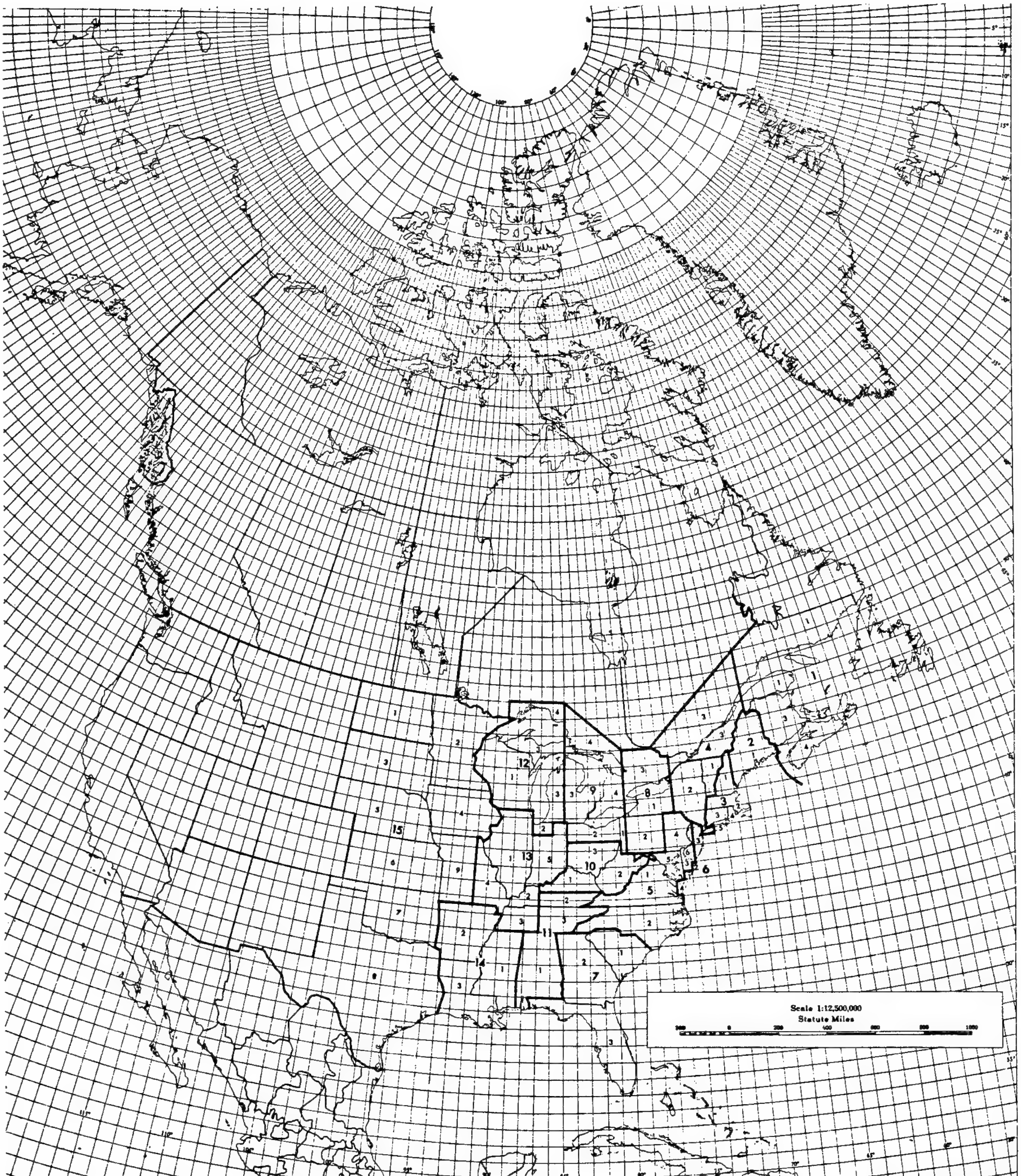



**Figure 3.** Banding reference areas representing the wintering black duck population. The large numbers relate to major reference areas; the smaller numbers relate to minor reference areas.

Table 2. *Total number of recoveries taken in each harvest area and the percent that were reported to the Bird Banding Laboratory by the hunter (direct and indirect recoveries from all banding periods, sexes, and ages combined).*

| Harvest areas | Years | Number of recoveries | Percent reported by hunters a | Percent reported by govt. agency[1] b | Percent misc.[2] c | Adjusted percent reported by hunter[3] | Adjusted percent reported by govt. agency[3] |
|---|---|---|---|---|---|---|---|
| Canada | | | | | | | |
| AB 04 | 1947–69 (2)[4] | 2 | 50 | 0 | 50 | 50 | 50 |
| BC 11 | 1976 (1) | 1 | 100 | 0 | 0 | 100 | 0 |
| NW 43[5] | 1956 (1) | 1 | 100 | 0 | 0 | 100 | 0 |
| MB 45 | 1939–76 (27) | 110 | 44 | 9 | 47 | 83 | 17 |
| NB 56 | 1928–76 (20) | 2,509 | 59 | 28 | 13 | 68 | 32 |
| NF 57 | 1947–66 (10) | 446 | 9 | 3 | 87 | 74 | 26 |
| NS 65 | 1922–77 (35) | 2,387 | 65 | 28 | 7 | 69 | 31 |
| ON 68 | 1918–76 (50) | 8,370 | 60 | 15 | 25 | 80 | 20 |
| PE 75 | 1942–76 (25) | 1,908 | 33 | 26 | 40 | 56 | 44 |
| QU 76 | 1931–76 (35) | 4,149 | 55 | 18 | 27 | 76 | 24 |
| SK 79 | 1945–76 (16) | 22 | 55 | 5 | 41 | 92 | 8 |
| NT 95[6] | 1956–66 (4) | 48 | 75 | 19 | 6 | 80 | 20 |
| **Totals** | | 19,953 | 56 | 20 | 25 | 74 | 26 |
| Atlantic Flyway | | | | | | | |
| CT 18 | 1922–76 (35) | 1,490 | 14 | 4 | 82 | 77 | 23 |
| DE 21 | 1938–76 (34) | 1,848 | 53 | 16 | 32 | 77 | 23 |
| DC 22 | 1935–38 (4) | 14 | 0 | 0 | 100 | 50 | 50 |
| GA 25 | 1936–70 (8) | 17 | 47 | 12 | 41 | 80 | 20 |
| FL 27 | 1963–70 (6) | 23 | 74 | 17 | 9 | 81 | 19 |
| ME 44 | 1921–77 (45) | 6,458 | 48 | 16 | 36 | 75 | 25 |
| MD 46 | 1931–76 (8) | 4,163 | 58 | 17 | 25 | 77 | 23 |
| MA 47 | 1923–76 (49) | 14,315 | 20 | 6 | 74 | 77 | 23 |
| NH 58 | 1948–71 (17) | 433 | 62 | 23 | 15 | 73 | 27 |
| NJ 59 | 1930–77 (34) | 3,737 | 66 | 15 | 20 | 82 | 18 |
| NY 61 | 1923–77 (54) | 18,398 | 36 | 11 | 52 | 76 | 24 |
| NC 63 | 1936–77 (36) | 1,225 | 64 | 18 | 18 | 78 | 22 |
| PA 72 | 1938–76 (26) | 2,237 | 36 | 9 | 55 | 80 | 20 |
| RI 77 | 1932–72 (22) | 868 | 49 | 16 | 36 | 76 | 24 |
| SC 80 | 1924–76 (36) | 542 | 48 | 10 | 42 | 83 | 17 |
| VT 87 | 1942–75 (33) | 2,667 | 54 | 18 | 27 | 75 | 25 |
| VA 88 | 1936–77 (37) | 1,163 | 60 | 12 | 28 | 83 | 17 |
| WY 90 | 1953–69 (16) | 179 | 58 | 12 | 30 | 83 | 17 |
| **Totals** | | 59,787 | 39 | 12 | 49 | 77 | 23 |
| Mississippi Flyway | | | | | | | |
| AL 02 | 1942–75 (30) | 655 | 61 | 17 | 22 | 78 | 22 |
| AR 07 | 1938–74 (21) | 133 | 65 | 14 | 22 | 83 | 17 |
| IL 34 | 1922–77 (45) | 4,028 | 28 | 5 | 67 | 84 | 16 |
| IN 35 | 1936–77 (33) | 1,569 | 1 | 51 | 49 | 1 | 99 |
| IA 36 | 1961–76 (9) | 22 | 91 | 9 | 0 | 91 | 9 |
| KY 39 | 1947–76 (18) | 349 | 69 | 19 | 12 | 79 | 21 |

Table 2. *Continued.*

| Harvest areas | Years | Number of recoveries | Percent reported by hunters a | Percent reported by govt. agency[1] b | Percent misc.[2] c | Adjusted percent reported by hunter[3] | Adjusted percent reported by govt. agency[3] |
|---|---|---|---|---|---|---|---|
| LA 42 | 1929–76 (13) | 18 | 44 | 0 | 56 | 100 | 0 |
| MI 49 | 1927–76 (49) | 9,088 | 20 | 7 | 73 | 75 | 25 |
| MN 50 | 1932–76 (30) | 459 | 70 | 17 | 13 | 80 | 20 |
| MS 51 | 1963–77 (12) | 70 | 81 | 16 | 3 | 84 | 16 |
| MO 52 | 1923–67 (22) | 84 | 42 | 11 | 48 | 80 | 20 |
| OH 66 | 1926–76 (37) | 2,188 | 42 | 12 | 46 | 78 | 22 |
| TN 82 | 1949–76 (28) | 3,841 | 68 | 20 | 11 | 77 | 23 |
| WI 91 | 1924–76 (43) | 1,079 | 42 | 9 | 48 | 82 | 18 |
| **Totals** | | 23,583 | 37 | 10 | 53 | 78 | 22 |
| Central Flyway | | | | | | | |
| KS 38 | 1957–75 (7) | 11 | 91 | 9 | 0 | 91 | 9 |
| MT 53 | 1939–65 (4) | 4 | 50 | 25 | 25 | 67 | 33 |
| NE 54 | 1967 (1) | 1 | 100 | 0 | 0 | 100 | 0 |
| NM 64 | 1940–73 (13) | 19 | 58 | 11 | 32 | 85 | 15 |
| OK 67 | 1939–67 (14) | 28 | 14 | 4 | 82 | 80 | 20 |
| SD 81 | 1937–66 (9) | 23 | 13 | 4 | 83 | 75 | 25 |
| TX 83 | 1966 (1) | 1 | 100 | 0 | 0 | 100 | 0 |
| **Totals** | | 87 | 37 | 7 | 56 | 84 | 16 |
| Pacific Flyway | | | | | | | |
| CA 14 | 1932–38 (3) | 24 | 0 | 0 | 100 | 50 | 50 |
| VT 85 | 1933 (1) | 1 | 0 | 0 | 100 | 50 | 50 |
| WA 89 | 1968 (1) | 1 | 0 | 100 | 0 | 0 | 100 |
| **Totals** | | 26 | 0 | 4 | 96 | 0 | 100 |

[1] Includes respondents to questionnaire survey.
[2] Reporting source not identified.
[3] Proportion of a and b in (a + b) were multiplied by c; the products were added to a and b, respectively.
[4] Inclusive banding years; number in parenthesis represents the actual number of years of banding.
[5] Mackenzie District, Northwest Territories.
[6] Keewatin District, Northwest Territories.

Also shown in Table 2 are the total numbers of recoveries by state or province, and the proportions of recoveries reported by the hunter, by government or conservation agencies, bird banders, or indirectly by hunters on the Hunter Questionnaire Survey. This information is of particular value for reward band study data analysis, since band recoveries reported by those agencies and individuals included in column 5 are assigned a reporting rate of 1.0 (assumes all recoveries are reported), whereas the main objective of reward band studies is to determine the band reporting rate of hunters ($0 < \delta < 1$).

The numbers of preseason bandings by age–sex groups for each major reference area are shown in Table 3. Similar data by states is presented in Appendix A (Table A-1). The major reference area bandings were used to describe the distribution of band recoveries (to be described in a later work). Discrepancies in the totals of Table 3 and Appendix Table A-1 resulted because the

Table 3. *Black duck preseason bandings (July 1–September 30) by major reference areas for the period 1918–1978 inclusive (normal wild birds only) showing the proportion of banding in each reference area (see Table 6 for complete reference area names).*

| Reference area | Adult Male | Adult Female | Young Male | Young Female | Total banding | Percent of all banding |
|---|---|---|---|---|---|---|
| Maritimes (01) | 791 | 1,394 | 10,555 | 9,664 | 22,404 | 11.1 |
| Lab & E Que (02) | 2,383 | 1,211 | 4,378 | 4,198 | 22,170 | 6.0 |
| N Que (03) | 23 | 4 | 110 | 74 | 211 | 0.1 |
| S Que (04) | 1,641 | 1,082 | 5,546 | 4,516 | 12,785 | 6.3 |
| St John & St Crox R (05) | 311 | 404 | 4,106 | 4,101 | 8,922 | 4.4 |
| W Maine (06) | 730 | 1,105 | 10,155 | 9,068 | 21,058 | 10.4 |
| Vt & NH (07) | 372 | 506 | 2,677 | 2,385 | 5,940 | 2.9 |
| Coastal Mass (08) | 1,385 | 1,907 | 4,487 | 3,907 | 11,686 | 5.8 |
| S New Eng (09) | 449 | 448 | 1,802 | 1,423 | 4,122 | 2.0 |
| Lake Champlain (10) | 664 | 489 | 4,452 | 3,417 | 9,022 | 4.5 |
| Chesapeake & Del Bays (11) | 1,434 | 1,212 | 4,953 | 3,536 | 11,135 | 5.5 |
| E Lake Ont (12) | 4,127 | 3,545 | 12,612 | 10,284 | 30,568 | 15.1 |
| W Lake Ont (13) | 2,158 | 1,415 | 9,366 | 6,135 | 19,074 | 9.4 |
| W James Bay (14) | 513 | 345 | 1,252 | 945 | 3,055 | 1.5 |
| Up Gt Lakes (15) | 2,141 | 1,246 | 5,426 | 3,777 | 12,590 | 6.2 |
| W Lake Erie (16) | 1,825 | 870 | 2,448 | 1,581 | 6,724 | 3.3 |
| E Lake Mich (17) | 519 | 380 | 721 | 557 | 2,177 | 1.1 |
| W Lake Mich (18) | 701 | 594 | 1,561 | 1,044 | 3,900 | 1.9 |
| Up Miss R (19) | 549 | 216 | 471 | 251 | 1,487 | 0.7 |
| NW (20) | 1,168 | 65 | 181 | 66 | 1,480 | 0.7 |
| Ohio & Miss Rivers (21) | 5 | 0 | 3 | 0 | 8 | tr.* |
| Central Mountains (22) | 1 | 0 | 0 | 0 | 1 | tr. |
| Southern (23) | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Piedmont (24) | 11 | 43 | 599 | 688 | 1,341 | 0.7 |
| Penn (25) | 196 | 42 | 93 | 73 | 404 | 0.2 |
| SE (26) | 0 | 0 | 0 | 2 | 2 | tr. |
| N Ont (27) | 19 | 4 | 3 | 0 | 26 | tr. |
| **Totals** | 24,116 | 18,527 | 87,957 | 71,692 | 202,292 | 99.8 |

* <0.1 percent.

tabulations by major reference area were constructed originally for a purpose other than the summation of banding records, and banding years in which no recoveries were reported were dropped from the data output. Corresponding data for the winter banding period are presented in Table 4 and Appendix Table A-2. These totals differ for the same reason given above.

Nearly three-fourths (72%) of the total preseason band recoveries were from young birds; 68% of them were direct recoveries. The adult direct recovery rate of preseason bandings was 44%. Direct recoveries represented 41% of all winter banding recoveries: 47% for males, 38% for females. Table 5 summarizes all preseason and winter bandings used in this study. In 1971 the black duck banding and recovery files were edited by the Bird Banding Laboratory and the Automatic Data Processing Section to identify and correct errors. Therefore, the files as used are as error-free as possible.

## *Delineation of Reference Areas*

Reference areas provide a convenient way to evaluate the characteristics of populations banded in adjacent locations. Individual banding station analysis is impractical because of the number of stations involved. Moreover,

Table 4. *Black duck winter bandings (January 1–February 28) by major reference areas for the period 1918–1978 inclusive (normal, wild birds only) showing the proportion of banding in each reference area (see Table 9 for complete reference area names).*

| Major reference area | Adult Males | Adult Females | Total bandings | Percent of all bandings |
|---|---|---|---|---|
| Maritimes (01) | 3,031 | 1,356 | 4,387 | 2.7 |
| Maine (02) | 3,810 | 1,729 | 5,539 | 3.4 |
| S New Eng (03) | 24,478 | 14,627 | 39,105 | 24.0 |
| LI & Hudson R (04) | 2,278 | 776 | 3,054 | 1.9 |
| Mid-Atl (05) | 16,547 | 11,631 | 28,178 | 17.2 |
| Mid-Atl C (06) | 16,129 | 11,247 | 27,376 | 16.7 |
| SE (07) | 989 | 957 | 1,946 | 1.2 |
| Lake Ont (08) | 4,244 | 2,190 | 6,434 | 3.9 |
| Lake Erie (09) | 5,565 | 2,213 | 7,778 | 4.7 |
| Up Ohio R (10) | 1,241 | 653 | 1,894 | 1.2 |
| Tenn R (11) | 5,022 | 3,501 | 8,523 | 5.2 |
| Lake Mich (12) | 3,336 | 1,935 | 5,271 | 3.2 |
| Up Miss R (13) | 13,387 | 9,700 | 23,087 | 14.1 |
| Lower Miss R (14) | 720 | 516 | 1,236 | 0.8 |
| Western Area (15) | 95 | 19 | 114 | 0.1 |
| **Totals** | 100,872 | 63,050 | 163,922 | 100.3 |

Table 5. *Summary of black duck bandings (normal, wild birds) for the preseason and winter banding periods of 1918 to 1978 inclusive showing the percent of total bandings (all status codes) used in this study.*

| Age | Preseason Bandings Male | Preseason Bandings Female | Total | Percent of total bandings |
|---|---|---|---|---|
| Local | 7,361 | 7,588 | 14,949 | 82.3 |
| Immature | 80,837 | 64,438 | 145,275 | 95.1 |
| Adult | 24,899 | 19,512 | 44,411 | 94.3 |
| **Totals** | 113,097 | 91,538 | 204,635 | 93.8 |

| Age | Winter Bandings Male | Winter Bandings Female | Total | Percent of total bandings |
|---|---|---|---|---|
| Immature | 60 | 34 | 94* | 95.9 |
| Adult | 105,388 | 66,515 | 171,903 | 95.4 |
| **Totals** | 105,448 | 66,549 | 171,997 | 95.4 |

* Birds banded after 31 December were recorded as adults.

combined data of banding stations with similar recovery and distribution characteristics provide more meaningful results. Reference areas do not constitute management areas, rather, they represent populations distinguishable on the basis of their distribution and recovery patterns. The reference areas used in this study were derived by Geis et al. (1971:12–22) by plotting individual band recoveries for direct and indirect recoveries from preseason and winter banding periods accomplished in degree blocks of latitude and longitude. Reference area designations were based on the recognition of similarities of the plotted distributions. For this study a 2 × n chi-square contingency test was used to compare recovery distributions between the periods 1945–1960 (Geis et al. 1971) and 1961–1975 using computer listings showing band recoveries by banding and recovery degree blocks. No substantial changes in recovery areas were noted, therefore the original reference areas were retained. However, significant increases were noted in the proportions of the total recoveries taken in preseason banding areas. This suggests more intensive hunting pressure on the breeding grounds. Two additional preseason major reference areas were added: Southeast (26) and Northern Ontario (7), but neither area provided sufficient band recovery data for analysis. The major reference areas (27) for preseason bandings are shown in Figure 2, those for winter reference areas (15) are shown in Figure 3. Tables 6 and 7 provide the names and code numbers for preseason and winter banding reference areas, respectively.

### *Harvest Areas*

A 2 × n chi-square contingency test was used to compare the derivation of recoveries of one state with the recovery derivation of individual adjacent states. This conditional procedure tested the similarity of the proportions of the states' band recoveries coming from the various source areas. The null hypothesis was that the proportional distribution of band recoveries from the various source areas was the same for the two tested states. A series of 2 × n tests was run. States were selected as initial test units because hunting regulations are estab-

Table 6. *Major and minor reference areas used in summarizing preseason banding data (the numeric codes correspond to the numbers on Figure 2).*

| Numeric code | Name of major reference area | Numeric code | Name of minor reference area |
|---|---|---|---|
| 01 | Maritimes | 011 | New Brunswick |
| | | 012 | Prince Edward Island |
| | | 013 | Nova Scotia |
| | | 014 | Newfoundland |
| 02 | Labrador & Eastern Quebec | 021 | Quebec |
| | | 022 | Labrador |
| | | 023 | New Brunswick |
| | | 024 | Labrador |
| | | 025 | Anticosti Island |
| 03 | Northern Quebec | 031 | Quebec |
| | | 032 | Ontario |
| 04 | Southern Quebec | 041 | Quebec |
| 05 | St. John & St. Croix R. | 051 | New Brunswick |
| | | 052 | Maine |
| 06 | Western Maine | 061 | Maine |
| 07 | Vermont & New Hampshire | 071 | New Hampshire |
| | | 072 | Vermont |
| 08 | Coastal Massachusetts | 081 | Massachusetts |
| 09 | Southern New England | 091 | Massachusetts |
| | | 092 | Connecticut |
| | | 093 | Rhode Island |
| | | 094 | New York |
| 10 | Lake Champlain | 101 | New York |
| | | 102 | Vermont |

Table 6. *Continued.*

| Numeric code | Name of major reference area | Numeric code | Name of minor reference area |
|---|---|---|---|
| 11 | Chesapeake & Delaware Bays | 111 | Pennsylvania |
| | | 112 | New Jersey |
| | | 113 | Delaware |
| | | 114 | Maryland |
| | | 115 | Virginia |
| 12 | Eastern Lake Ontario | 121 | Ontario |
| | | 122 | New York |
| 13 | Western Lake Ontario | 131 | Ontario |
| | | 132 | Quebec |
| | | 133 | New York |
| 14 | Western James Bay | 141 | Ontario |
| 15 | Upper Great Lakes | 151 | Ontario |
| | | 152 | Michigan |
| 16 | Western Lake Erie | 161 | Michigan |
| | | 162 | Ontario |
| | | 163 | Ohio |
| 17 | Eastern Lake Michigan | 171 | Michigan |
| | | 172 | Indiana |
| 18 | Western Lake Michigan | 181 | Michigan |
| | | 182 | Wisconsin |
| | | 183 | Illinois |
| | | 184 | Illinois |
| 19 | Upper Mississippi River | 191 | Ontario |
| | | 192 | North Dakota |
| | | 193 | Minnesota |
| | | 194 | South Dakota |
| | | 195 | Wisconsin |
| 20 | Northwest | 201 | Manitoba |
| | | 202 | Minnesota |
| | | 203 | Saskatchewan |
| | | 204 | Alberta |
| 21 | Ohio & Mississippi Rivers | 211 | Illinois |
| | | 212 | Indiana |
| | | 213 | Missouri |
| | | 214 | Kentucky |
| | | 215 | Tennessee |
| 22 | Central Mountains | 221 | Ohio |
| | | 222 | West Virginia |
| | | 223 | Kentucky |
| 23 | Southern | 231 | Kentucky |
| | | 232 | Tennessee |
| | | 233 | Alabama |
| 24 | Piedmont | 241 | Maryland |
| | | 241 | Virginia |
| | | 243 | North Carolina |
| 25 | Pennsylvania | 251 | Pennsylvania |
| 26 | Southeast | 261 | South Carolina |
| | | 262 | Georgia |
| | | 263 | Florida |
| 27 | Northern Georgia | 271 | Ontario |

Table 7. *Major and minor reference areas used in summarizing winter banding data (the numeric codes correspond to the numbers on Figure 3).*

| Numeric Code | Name of major reference area | Numeric code | Name of minor reference area |
|---|---|---|---|
| 01 | Maritimes | 011 | Quebec |
| | | 012 | Prince Edward Island |
| | | 013 | New Brunswick |
| | | 014 | Nova Scotia |
| | | 015 | Newfoundland |
| 02 | Maine | 021 | Maine |
| 03 | Southern New England | 031 | New Hampshire |
| | | 032 | Massachusetts |
| | | 033 | Connecticut |
| | | 034 | Rhode Island |
| | | 035 | Vermont |
| | | 036 | New York (Long Isl) |
| 04 | Western Long Island & Hudson River | 041 | Vermont |
| | | 042 | New York |
| | | 043 | Quebec |
| | | 044 | Ontario |
| 05 | Mid-Atlantic | 051 | Virginia |
| | | 052 | North Carolina |
| | | 053 | Delaware |
| | | 054 | Pennsylvania |
| | | 055 | Maryland |
| | | 056 | New Jersey |
| 06 | Mid-Atlantic Coastal | 061 | Maryland |
| | | 062 | Delaware |
| | | 063 | New Jersey |
| | | 064 | Virginia |
| 07 | Southeast | 071 | South Carolina |
| | | 072 | Georgia |
| | | 073 | Florida |
| 08 | Lake Ontario | 081 | New York |
| | | 082 | Pennsylvania |
| | | 083 | Ontario |
| 09 | Lake Erie | 091 | Pennsylvania |
| | | 092 | Ohio |
| | | 093 | Michigan |
| | | 094 | Ontario |
| 10 | Upper Ohio River | 101 | Kentucky |
| | | 102 | West Virginia |
| | | 103 | Ohio |
| 11 | Tennessee River | 111 | Alabama |
| | | 112 | Kentucky |
| | | 113 | Tennessee |
| 12 | Lake Michigan | 121 | Wisconsin |
| | | 122 | Indiana |
| | | 123 | Michigan |
| | | 124 | Ontario |
| 13 | Upper Mississippi River | 131 | Illinois |
| | | 132 | Kentucky |
| | | 133 | Tennessee |

Table 7. *Continued.*

| Numeric Code | Name of major reference area | Numeric code | Name of minor reference area |
|---|---|---|---|
| | | 134 | Missouri |
| | | 135 | Indiana |
| 14 | Lower Mississippi River | 141 | Mississippi |
| | | 142 | Arkansas |
| | | 143 | Louisiana |
| 15 | Western Area | 151 | North Dakota |
| | | 152 | Minnesota |
| | | 153 | South Dakota |
| | | 154 | Iowa |
| | | 155 | Nebraska |
| | | 156 | Kansas |
| | | 157 | Oklahoma |
| | | 158 | Texas |
| | | 159 | Missouri |

lished at the state level within each flyway, and because the use of political boundaries is adequate for studying the distribution of band recoveries, general migration routes, and the speed and timing of migration. All states except Massachusetts and Rhode Island showed significant differences, therefore individual states have been used as harvest areas.

## *Estimation of Parameters*

### Problems in the Use of Banding Data

Errors in the data source, particularly prior to 1950 when aging and sexing techniques were not well described nor widely known may have resulted in some inaccuracies in data interpretation. However, less than 5% of the total data base is represented in the 1918–1950 period, therefore the analysis as presented is based on data largely free of these errors.

Previous methods of estimating survival rates were biased seriously by band loss, or by band reporting rate changes or trends. Fortunately, the modern methods described in Brownie et al. (1978) are not affected substantially by either band loss or reporting rate changes. Now the most serious difficulty is that the large sampling variances associated with many of the population parameter estimates reduce the power of the statistical tests, and often preclude drawing a firm conclusion from a hypothesis test.

### Limitations of the Data

The models used in this study require a minimum of 300 adult bandings (each sex) annually for each cohort, if reasonably precise recovery and survival estimates are to be derived (Brownie et al. 1978:190). This ''rule of thumb'' was intentionally violated numerous times (Appendixes B–D) to provide some information whenever the data source would provide a successful ''run'' of the computer program (Program Brownie—preseason bandings or Program Estimate—winter bandings). A frustrating occurrence in the black duck banding file was the disruption in the sequence of banding years caused by the lack of, or insufficient, bandings in a particular year. This problem was common to all data sets whether by state/province, major, or minor reference area, and relates to a reduction in banding effort, or an unsuccessful banding effort in a given year or series of years. Brownie et al. (1978:185) recommend at least 5 consecutive years of banding data. The banding file also lacks sufficient numbers of adult preseason bandings. This is true particularly for adult females, even in areas where banding effort has been intensive. In addition to these problems, entire segments of the black duck population, notably those breeding in the northern boreal forest regions of Canada, are not represented by banded samples. It is unlikely under present economic conditions and resource funding priorities that this problem will be corrected in the near future.

The estimates of band reporting rates used in this

study to determine the proportion of total mortality attributable to hunting were adjusted for nonreporting based on preliminary unpublished results from the Black Duck Reward Band Study. The United States correction factors from the Hunter Questionnaire Survey differ from the preliminary reward band study estimates. The current band reporting rate as measured by the reward band study is 24% higher than the Hunter Questionnaire estimate (0.49, ± 0.14, Reward Band estimate vs. about 25%, Hunter Questionnaire Survey).

# Part II.

## Statistical Analysis of Population Characteristics of Banded Black Ducks and Geographic Variation in Recovery and Survival Rates

# Methods

## *Recovery and Survival Rates*

Arguments favoring the so-called "modern methods" are presented in detail by Anderson (1975), Anderson and Burnham (1976:12–13), Burnham and Anderson (1979), and Eberhardt (1972). The models used in this study were developed by several mathematical statisticians (Seber 1970; Robson and Youngs 1971; Brownie and Robson 1974, 1976) and have been presented collectively with related statistical testing procedures in "Statistical Inference from Band Recovery Data—A Handbook" (Brownie et al. 1978). Table 8 provides a description of the assumptions underlying each of the "Brownie" and "Estimate" models. As outlined by Anderson and Burnham (1976:18), modern methods are based on a general stochastic model structure, and define explicit assumptions amenable to a chi-square goodness of fit test, which allows testing of the assumptions between models and permits the selection of a "best" fitting model. Because recovery and survival estimates are based on the method of Maximum Likelihood, the estimators are "fully efficient" (no other consistent estimators have a smaller asymptotic variance under the assumptions of a particular model). Estimates of survival rates are not biased by annual changes in recovery rates in these models; in addition, annual recovery rates and survival rates may be obtained from several models under varying assumptions. The capability of the models to compute estimates of sampling variances and covariances provides a measure of precision and interdependence of recovery and survival rates, and permits the construction of statistical tests of the null hypothesis that the average survival in two groups (e.g., two geographic areas, sets of years, age–sex classes) is equal. An extensive series of such tests was made using the $z$ test statistic:

$$z = \frac{(\hat{S}_1 - \hat{S}_2)}{\sqrt{\mathrm{Var}\,(\hat{S}_1) + \mathrm{Var}\,(\hat{S}_2) - 2\,\mathrm{Cov}\,(\hat{S}_1, \hat{S}_2)}}$$

This method was employed also to test the null hypothesis that there is no difference in years of restrictive hunting regulations compared to years of liberal regulations:

$$z = \frac{(\hat{S}_{Res} - \hat{S}_{Lib})}{\sqrt{\mathrm{Var}\,(\hat{S}_{Res}) + \mathrm{Var}\,(\hat{S}_{Lib}) - 2\,\mathrm{Cov}\,(\hat{S}_{Res}, \hat{S}_{Lib})}}$$

A composite test statistic for each age and sex class was formed by pooling the test statistics as

$$z = \frac{\sum_{i=1}^{n} Z_i}{\sqrt{n}}$$

Under the null hypothesis, $z$ is distributed approximately as Normal (0.1).

The hypothesis of a constant annual survival rate ($H_0 = S_1 = S_2 = S_{k-1}$, where k is the last year of banding in an experiment) was tested by comparing Model 1 and Model 2. A comparison of Model 1 versus Model 2 via a likelihood ratio test constitutes a test of the constant survival hypothesis, given that Model 1 fits the data. These tests are approximately distributed as chi-square under the null hypothesis (Anderson and Burnham 1976:18; Brownie et al. 1978:39).

Chi-square statistics were used also to test hypotheses concerning the similarity of recovery and survival rates by sex classes (Brownie et al. 1978:144–152). In addition, the $z$ test statistic was used to test several hypotheses related to the equality of age-specific and sex-specific parameters over years and areas (Brownie et al. 1978:180–182).

## *Hunting as a Mortality Factor*

The proportion of total mortality attributable to hunting mortality was calculated using the formula

$$\hat{M}_h = \frac{\hat{f}}{(1 - \hat{c})\,\hat{\delta}}(1 - \hat{S})$$

where

$\hat{M}_h$ = the average annual proportion of the total mortality caused by hunting

$\hat{f}$ = the average annual recovery rate

$\hat{c}$ = the average annual crippling loss, or the proportion of downed birds not retrieved = 17%

$\hat{\delta}$ = average annual band reporting rate = 40% for the United States, 32% for Canada

$\hat{S}$ = the average annual survival rate

Table 8. *Assumptions of the models for adult banded birds only (Estimate Models) and adult and young banded birds (Brownie Models) relative to the variation of the recovery rate (f)*[1] *and the survival rate (S) parameters.*

Estimate models (adult birds only):

Model 0
1. Annual recovery and survival rates are time-specific.
2. First year recovery rates are different from recovery rates of previously banded cohorts.
3. Recovery and survival rates are age-independent.

Model 1
1. Annual recovery and survival rates are time-specific but independent of the year of banding, thus $f_i$ and $S_i$ relate to a specific year.
2. Recovery and survival rates are age-independent.

Model 2
1. Annual recovery rates are time-specific ($f_i$).
2. Survival rates are constant ($S$).
3. Recovery and survival rates are age-independent.

Model 3
1. Recovery ($f$) and survival ($S$) rates are constant and age-independent.

Brownie models (young and adult birds):

Model $H_1$
1. Annual recovery ($f_i$) and survival ($S_i$) rates are year-specific.
2. Young birds have different recovery ($f'_i$) and survival ($S'_i$) rates from those of adults.

Model $H_2$
1. Annual recovery ($f_i$) and survival ($S_i$) rates are year-specific.
2. Young birds have different recovery and survival rates from those of adults.
3. In any year, the reporting rate for new releases is different from that for survivors of previously banded cohorts, and hence the corresponding recovery rates are different ($f_i$, $f'_i$, $f''_i$).

Model $H_3$
1. Annual recovery ($f_i$) and survival ($S_i$) rates are year-specific.
2. Recovery and survival rates are age-dependent for the first 2 years of life. (This embraces assumption (3) of $H_2$ for the type of data being analyzed.)

Model $H_0$
1. Recovery rates ($f_i$) and survival rates ($S_i$) are year-specific, but independent of age.

Model $H_{01}$
1. Young and adults have different recovery rates ($f$, $f'$) and survival ($S$, $S'$) rates.
2. Recovery rates and survival rates are constant from year to year.

Model $H_{02}$
1. Young and adults have different recovery ($f$, $f'$) and survival ($S$, $S'$) rates.
2. Survival rates are constant from year to year.
3. Recovery rates ($f_i$, $f'_i$) are year-specific.

[1] The assumptions pertaining to recovery rates imply that the same assumptions are true for harvest rates (H) and reporting rates ($\delta$).

The crippling loss value (17%) was calculated from Hunter Performance Survey data on black ducks (Files, Office of Migratory Bird Management). Although this value is lower than crippling loss rates reported by other workers (Boyd 1971, 22.7% for black ducks; Martin and Carney 1977:33, 19.7% for all ducks), it agrees almost exactly with the crippling loss values derived from Hunter Questionnaire Survey data before the correction factor for reporting bias ("prestige bias") is applied.

The band reporting rates are preliminary estimates computed by Dr. M. J. Conroy (Migratory Bird and Habitat Research Laboratory, USFWS) from the Black Duck Reward Band Study data. The actual U.S. reporting rate estimate for all recoveries from preseason and winter banding periods averaged 0.49 with standard error = 0.14. Because the standard error was so large, because the 1972 mallard reward band study (Henny and Burnham 1976) indicated a mallard band reporting rate of 41% in the Atlantic Flyway, and because the band reporting rate estimate for eastern Canada was substantially lower, I arbitrarily selected the value of 40%. Its effect on $M_h$, however, is to exaggerate that value, if in fact the true reporting rate is closer to 49%. The Canadian band reporting rate of 0.32 was measured with standard error = 0.04.

The theory of compensatory mortality defined by Anderson and Burnham (1976:5–6,11) postulates that hunting mortality and nonhunting mortality are related inversely if hunting mortality is below a critical threshold point, C. I examined the question of compensatory mortality for black ducks by comparing the preseason recovery rate (f) of populations that supply birds to a particular wintering ground, with the early winter:late winter recovery rate ratio of winter banded birds. Early winter banded birds are defined by the period 15 December through 31 January; late winter banded birds are defined by the period 1 February through 15 March. Hunting seasons were closed in all areas at banding time.

High preseason recovery rates ( = high harvest rates) are associated with high hunting mortality (Tables 26–29). If compensation for high hunting mortality occurs on the wintering grounds, the recovery rates of birds banded at two different wintering periods (early vs. late) will be closer to 1.0 than if compensation does not occur. This results from a positive change in the survival of winter-banded birds which is expressed more strongly in the early banded wintering birds because they have experienced the compensating mechanism over a longer time period than the late-banded wintering birds. Furthermore, if compensation on the wintering ground is influenced by high hunting mortality of preseason banded populations, then a direct, positive relationship exists between the preseason recovery rate and the early winter:late winter recovery rate ratio. A correlation analysis to test this hypothesis was performed using data from several areas.

# Results

## *Temporal Variation in Recovery and Survival Rates*

Waterfowl hunting regulations have varied greatly over the years in response to the annual population status of various waterfowl species, especially the mallard (Patterson 1979; Rogers et al. 1979; Martin and Carney 1977; Geis et al. 1969). The result has been substantial variation in harvest pressure among years and geographic areas, which suggests that recovery rates and survival rates also may vary by year and geographic area. Appendix Tables B, C, and D present estimates of these parameters derived from preseason bandings for young and adult black ducks. Recovery and survival estimates for winter banded adult black ducks are shown in Appendix Tables E through G. Estimates are provided for three types of reference areas: (1) State/Province, (2) Major Reference Area, and (3) Minor Reference Area. The tests of hypotheses related to geographic and temporal variation in recovery and survival rates of banded populations are described by Anderson (1975:7) and Brownie et al. (1978:180).

Model 3 ($M_3$; Brownie et al. 1978:24) is the simplest age-independent model of band recoveries. It is used to test the hypothesis that recovery rates and survival rates of black ducks are constant from year to year and independent of the age of the bird. Data for adults from six states, six major reference areas, and four minor reference areas were analyzed for constant survival rates using Model 3 (partial duplication of data sets occurs, e.g., Eastern Lake Ontario (12) bandings provide a part of the data in the state/province data sets for New York and Ontario as well as comprise the total data sets for two minor reference areas, Ontario (121) and New York (122)). Minor reference area data sets from preseason bandings generally were inadequate for use in the Brownie models for lack of sufficient annual bandings by age–sex classes. Minor Reference area winter banding data were adequate in most geographic areas.

The null hypothesis that recovery rates and survival rates are constant was tested using a chi-square goodness of fit test of Model 3 (Anderson 1975:8). Tables 9 and 10 show the test results. Rejection of the null hypothesis is convincing for both sexes for preseason bandings. Therefore, either recovery rates or survival rates or both of

Table 9. *Results of the test of the hypothesis that survival and recovery rates of adult black ducks are constant (preseason bandings).*

| Reference areas | Males df | Males $X^2$ | Females df | Females $X^2$ |
|---|---|---|---|---|
| State/Province | | | | |
| Maine | 21 | 54.77*** | 32 | 86.26*** |
| Massachusetts | 24 | 53.94*** | — | — |
| Michigan | 15 | 13.99 | — | — |
| New York | 116 | 298.87*** | 55 | 115.21*** |
| Ontario | 109 | 301.77*** | 63 | 151.82*** |
| Quebec | 101 | 299.76*** | 27 | 81.62*** |
| **Totals** | 386 | 1,023.10*** | 177 | 434.91*** |
| Major | | | | |
| Maritimes (01) | — | — | 21 | 50.33*** |
| Lab & E Que (02) | 15 | 22.46* | — | — |
| S Que (04) | 53 | 184.63*** | 27 | 68.03*** |
| E Lake Ont (12) | 117 | 281.29*** | 82 | 232.65*** |
| W Lake Ont (13) | 63 | 179.47*** | 16 | 34.25*** |
| Up Gt Lakes (15) | 44 | 53.64 | — | — |
| **Totals** | 292 | 721.49*** | 146 | 385.26*** |
| Minor | | | | |
| Quebec (041) | 61 | 199.71*** | 27 | 68.03*** |
| New York (122) | 91 | 193.64*** | 47 | 99.00*** |
| Ontario (131) | 63 | 136.67*** | — | — |
| Ontario (151) | 31 | 42.37 | — | — |
| **Totals** | 246 | 572.39*** | 74 | 167.03*** |

*$\alpha < 0.1$; ***$\alpha < 0.01$.

these parameters vary significantly from year to year based on the preseason banding data. The null hypothesis was rejected for winter banded males, but could not be rejected for winter banded adult females at the state level (Table 10). Rejection of the null hypothesis in the major reference area ($P < 0.01$) implies that recovery and survival rates of winter banded females are not constant. Significance ($P < 0.05$) indicated for the minor reference area test is based on Massachusetts(032) data alone and is not convincing. However, based on the major reference area results, I conclude that recovery and survival rates of winter banded females are not constant.

The constancy of first-year recovery rates was examined using a 2 × n chi-square contingency test. Test results are summarized in Table 11 for preseason bandings and in Table 12 for winter bandings. Major reference area banding data were used for the analysis to ensure adequate sample size. With the exception of the adult male and adult female preseason bandings, the null hypothesis that first-year recovery rates are constant is clearly rejected. The total chi-square value for adult females obtained by summing the degrees of freedom and the chi-square values over areas is rejected ($P < 0.1$) but the test results are not convincing. The total chi-square value for adult males is not significant although six major reference areas show statistically significant differences, suggesting that adult male recovery rates do vary from year to year in at least some areas. I conclude that annual variation in recovery rates of males and females does occur, but that the degree of variation is not great. Anderson (1975:9) found a significant difference in annual recovery rates for preseason adult mallards ($P < 0.01$, both sexes). However, mallard hunting regulations have

Table 10. *Results of the test of the hypothesis that survival and recovery rates of adult black ducks are constant (winter bandings).*

| Reference areas | Males | | Females | |
|---|---|---|---|---|
| | df | $X^2$ | df | $X^2$ |
| **State** | | | | |
| Delaware | 38 | 38.35 | 14 | 14.40 |
| Illinois | 25 | 28.04 | 20 | 24.83 |
| Maine | — | — | 11 | 9.62 |
| Maryland | 43 | 55.06 | 25 | 28.04 |
| Massachusetts | 71 | 162.05*** | 66 | 85.00* |
| New Jersey | 92 | 120.75** | 59 | 57.49 |
| New York | 142 | 253.17*** | 52 | 58.99 |
| North Carolina | 66 | 69.00 | 35 | 45.62 |
| Ohio | 28 | 33.38 | 12 | 10.70 |
| Tennessee | 88 | 122.65*** | 61 | 59.79 |
| Virginia | 55 | 77.38** | 37 | 31.24 |
| **Totals** | 648 | 959.83*** | 392 | 425.72 |
| **Major** | | | | |
| Maritimes (010) | 12 | 13.68 | — | — |
| Maine (020) | — | — | 11 | 9.62 |
| S New Eng (030) | 51 | 128.11*** | 74 | 108.75*** |
| LI-Hudson R (040) | 10 | 12.32 | — | — |
| Mid-Atl (050) | 139 | 179.58** | 51 | 87.43*** |
| Mid-Atl C (060) | 129 | 184.70*** | 90 | 113.37** |
| Lake Ont (080) | 62 | 102.70*** | — | — |
| Lake Erie (090) | 23 | 16.93 | — | — |
| Tenn R (110) | 72 | 79.84 | 48 | 65.14* |
| Lake Mich (120) | 20 | 20.47 | — | — |
| Up Miss R (130) | 73 | 106.40*** | 52 | 66.33* |
| **Totals** | 579 | 831.05*** | 326 | 450.64*** |
| **Minor** | | | | |
| Maine (021) | — | — | 11 | 9.62 |
| NH (031) | 1 | 0.00 | — | — |
| Mass (032) | 14 | 31.49*** | 55 | 73.49** |
| NY-LI (036) | — | — | 36 | 36.88 |
| NY (042) | 8 | 11.09 | — | — |
| Va (051) | 47 | 70.44** | 29 | 38.07 |
| NC (052) | 67 | 69.43 | 35 | 45.62 |
| Del (053) | 16 | 10.48 | — | — |
| Md (055) | 42 | 56.68* | 30 | 33.40 |
| NJ (063) | 91 | 117.81** | 58 | 59.47 |
| Va (064) | 22 | 23.87 | — | — |
| NY (081) | 56 | 97.98*** | — | — |
| Tenn (113) | 70 | 80.53 | 46 | 52.24 |
| Mich (123) | 27 | 24.12 | — | — |
| Ill (131) | 25 | 28.04 | 20 | 24.83 |
| Tenn (133) | 72 | 88.20 | 42 | 37.95 |
| **Totals** | 558 | 710.16*** | 362 | 411.57** |

*$\alpha < 0.1$; **$\alpha < 0.05$; ***$\alpha < 0.01$.

Table 11. *Test of the hypothesis that the 1st year recovery rates of adult and young black ducks are constant within a specific major reference area (preseason bandings)*

| Reference areas | Adult males | | Adult females | | Young males | | Young females | |
|---|---|---|---|---|---|---|---|---|
| | df | $\chi^2$ | df | $\chi^2$ | df | $\chi^2$ | df | $\chi^2$ |
| Maritimes (01) | 6 | 8.53 | 11 | 14.36 | 23 | 63.45*** | 21 | 68.42*** |
| Lab & E Que (02) | 21 | 12.42 | 8 | 4.72 | 28 | 53.14*** | 27 | 45.59** |
| S Que (04) | 8 | 7.33 | 6 | 12.18* | 16 | 31.54** | 16 | 36.95*** |
| St John & St Crox R (05) | — | — | — | — | 22 | 54.50*** | 21 | 44.93*** |
| W Maine (06) | 3 | 0.71 | 8 | 7.29 | 27 | 60.08*** | 26 | 52.87*** |
| Vt & NH (07) | — | — | — | — | 15 | 18.34 | 16 | 20.21 |
| C Mass (08) | 11 | 19.13* | 11 | 13.66 | 19 | 58.13*** | 18 | 75.15*** |
| S New Eng (09) | 2 | 10.37*** | 2 | 5.64* | 9 | 5.24 | 8 | 13.22 |
| Lake Champlain (10) | 3 | 7.59* | — | — | 21 | 24.89 | 19 | 39.76*** |
| Chesapeake & Del Bays (11) | 12 | 11.10 | 8 | 9.50 | 21 | 36.60** | 19 | 38.81*** |
| E Lake Ont (12) | 24 | 20.54 | 25 | 28.95 | 27 | 36.97* | 26 | 83.53*** |
| W Lake Ont (13) | 16 | 10.00 | 11 | 9.47 | 23 | 26.15 | 22 | 26.90 |
| W James Bay (14) | — | — | — | — | 11 | 15.84 | 6 | 11.80 |
| Up Gt Lakes (15) | 14 | 12.08 | 7 | 10.87 | 33 | 100.24*** | 29 | 57.90*** |
| W Lake Erie (16) | 12 | 6.47 | 4 | 4.30 | 20 | 19.44 | 13 | 12.55 |
| E Lake Mich (17) | — | — | — | — | 3 | 3.53 | 2 | 2.56 |
| W Lake Mich (18) | 2 | 6.15** | 3 | 1.93 | 12 | 31.39*** | 5 | 7.95 |
| Up Miss R (19) | 2 | 7.04** | — | — | 2 | 7.54** | — | — |
| NW (20) | 5 | 10.39* | — | — | — | — | — | — |
| **Totals** | 141 | 149.85 | 104 | 122.87* | 332 | 647.01*** | 294 | 639.10*** |

$*\alpha < 0.1$; $**\alpha < 0.05$; $***\alpha < 0.01$.

Table 12. *Test of the hypothesis that the 1st year recovery rates of adult black ducks are constant within a specific major reference area (winter bandings).*

| Reference areas | Males | | Females | |
|---|---|---|---|---|
| | df | $\chi^2$ | df | $\chi^2$ |
| **Major** | | | | |
| Maritimes (01) | 8 | 6.66 | 7 | 9.46 |
| Maine (02) | 10 | 52.95*** | 8 | 27.38*** |
| S New Eng (03) | 36 | 80.74*** | 33 | 47.87** |
| W LI & Hudson R (04) | 15 | 28.40** | 7 | 5.98 |
| Mid-Atl (05) | 27 | 33.93 | 26 | 42.28** |
| Mid-Atl C (06) | 27 | 67.73*** | 24 | 53.92*** |
| SE (07) | 7 | 6.74 | 6 | 1.94 |
| Lake Ont (08) | 20 | 34.43** | 16 | 15.07 |
| Lake Erie (09) | 25 | 21.35 | 12 | 12.80 |
| Up Ohio R (10) | 10 | 9.44 | 6 | 9.05 |
| Tenn R (11) | 15 | 12.32 | 13 | 12.37 |
| Lake Mich (12) | 11 | 14.63 | 10 | 20.99** |
| Up Miss R (13) | 17 | 28.26** | 16 | 31.63** |
| Lower Miss R (14) | 4 | 3.74 | 2 | 0.82 |
| **Totals** | 232 | 401.32*** | 186 | 291.56*** |

$*\alpha < 0.05$; $***\alpha < 0.01$.

been more variable in recent years than black duck hunting regulations, therefore mallard recovery rates would be expected to vary more. The winter banding test results (Table 12) which also reflect variations in survival between the time of banding and the first hunting season indicate significant variation in the annual recovery rates of both sexes.

Model 2 (Brownie et al. 1978:20) was developed under the hypothesis that recovery rates vary from year to year but that survival is constant in a given area. A goodness-of-fit test is used to evaluate each data set with respect to how well Model 1 and Model 2 describe the observed data, i.e., how well the parameter estimates of the observed data and their sampling variances and covariances are described by the model with its particular assumptions (Brownie et al. 1978:19; see Table 8). The test between Model 1 and Model 2 is a likelihood ratio test which is approximately distributed as chi-square under the null hypothesis. The null hypothesis is that the more simple model (least restrictive model, in this case $M_1$) fits the data (Brownie et al. 1978:39). Results of the tests for preseason bandings are shown in Table 13. The hypothesis of constant survival rate could not be rejected for a single data set, nor was the total chi-square value statistically significant. In fact, in most cases the data fit Model 2 ($M_2$) better than they fit Model 1 ($M_1$). Model 1, which assumes independent but year-specific recovery and survival rates, is rejected in some cases, and the likelihood ratio test is invalid for these situations since the alternative hypothesis is unknown (Anderson 1975:9). The tests using winter bandings (Table 14) showed similar results with the exception of major reference area data for adult females. The hypothesis that survival rates of adult females are constant was rejected in all six major reference area tests, and the total chi-square test was highly significant ($P < 0.01$). The results may reflect greater variability in breeding grounds mortality among females than among males. Intuitively, some annual variation in survival rates seems appropriate although annual differences may not be large. However, with respect to black duck survival rates, Anderson's conclusion (1975:9) concerning mallards is relevant, i.e., the mean estimate of survival ($\hat{S}$) is probably the best survival estimate for any given year as opposed to annual estimates, $S_i$, which have large variances.

The "correct" (best fit) model for each preseason data set is shown in Appendix Tables B, C, and D. However, Model 1 annual recovery and survival rate estimates were used for the statistical tests (*z* tests, chi-square tests) whenever the data fit Model 1 because the model provides annual estimates of recovery and survival, whereas some of the "best fit" models provide only average annual estimates. Neither Model 1 nor Model 2 is appropriate for preseason banding data from Ontario, nor does the Massachusetts preseason data for adult females fit either model. A summary of recovery rates and survival rates derived from the Brownie and Estimate models is given in Table 15 for preseason bandings and in Table 16 for winter bandings.

## *Sources of Variation*

Substantial variation in recovery rates and survival rates is demonstrated in Appendixes B through G. To determine if the observed variability was associated with years or geographic areas, a series of *z* tests (Brownie et

Table 13. *Results of testing the hypothesis that both recovery and survival rates of adult black ducks vary time-specifically (M1, Seber-Robson-Youngs) versus the hypothesis that recovery rates vary time-specifically but that survival is constant ($M_2$) (preseason bandings).*

| | Males | | | | | | Females | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fit of $M_1$ | | Fit of $M_2$ | | $M_2$ vs. $M_1$ | | Fit of $M_1$ | | Fit of $M_2$ | | $M_2$ vs. $M_1$ | |
| Reference areas | df | $\chi^2$ | df | $\chi^2$ | df | $\chi^2$ | df | $\chi^2$ | df | $\chi^2$ | df | $\chi^2$ |
| Maine | — | — | — | — | — | — | 1 | 4.44** | 5 | 4.52 | 4 | 1.22 |
| Massachusetts | 9 | 11.79 | 10 | 11.18 | 2 | 0.34 | 1 | 5.56** | 3 | 6.57* | 2 | 1.16 |
| New York | 41 | 54.28* | 53 | 58.77 | 11 | 8.10 | 11 | 11.28 | 17 | 14.65 | 5 | 3.82 |
| Ontario | 44 | 68.81*** | 56 | 72.57* | 12 | 4.60 | 14 | 24.69** | 20 | 31.53** | 7 | 10.02 |
| Quebec | 40 | 45.38 | 53 | 64.68 | 11 | 15.53 | 11 | 4.87 | 13 | 5.60 | 2 | 0.65 |
| **Totals** | 134 | 180.26* | 162 | 207.20 | 36 | 28.57 | 38 | 50.84 | 58 | 62.87 | 20 | 16.87 |

*$\alpha < 01$; **$\alpha < 0.05$; ***$\alpha < 0.01$.

Table 14. *Results of testing the hypothesis that both recovery and survival rates of adult black ducks vary time-specifically ($M_1$, Seber-Robson-Youngs) versus the hypothesis that recovery rates vary time-specifically but that survival is constant ($M_2$) (winter bandings).*

| | Males | | | | | | Females | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fit of $M_1$ | | Fit of $M_2$ | | $M_2$ vs. $M_1$ | | Fit of $M_1$ | | Fit of $M_2$ | | $M_2$ vs. $M_1$ | |
| Reference areas | df | $\chi^2$ | df | $\chi^2$ | df | $\chi^2$ | df | $\chi^2$ | df | $\chi^2$ | df | $\chi^2$ |
| **State** | | | | | | | | | | | | |
| Delaware | 22 | 14.84 | 27 | 27.00 | 4 | 8.74* | 4 | 4.36 | 7 | 6.70 | 2 | 1.64 |
| Illinois | 15 | 14.26 | 16 | 14.07 | 2 | 1.26 | 9 | 18.22 | 12 | 22.05** | 2 | 4.01 |
| Maine | 12 | 6.41 | 14 | 9.44 | 2 | 3.62 | 4 | 3.94 | 5 | 7.33 | 1 | 4.46 |
| Maryland | 28 | 37.80 | 33 | 40.20 | 5 | 3.41 | 10 | 17.46 | 14 | 20.24 | 5 | 3.33 |
| Massachusetts | 37 | 52.14* | 43 | 59.77** | 6 | 10.03 | 38 | 35.00 | 51 | 55.58 | 12 | 29.43 |
| New Jersey | 65 | 71.71 | 77 | 82.81 | 12 | 11.39 | 36 | 29.39 | 46 | 41.66 | 10 | 12.90 |
| New York | 106 | 114.05 | 122 | 155.03 | 18 | 47.97*** | 29 | 31.28 | 37 | 35.36 | 8 | 3.53 |
| North Carolina | 41 | 39.33 | 53 | 52.99 | 9 | 10.87 | 17 | 27.68 | 24 | 33.77* | 8 | 15.17* |
| Ohio | 16 | 14.89 | 20 | 20.74 | 4 | 6.68 | 2 | 0.84 | 5 | 2.90 | 2 | 2.63 |
| Tennessee | 66 | 68.75 | 75 | 80.43 | 8 | 12.10 | 42 | 35.63 | 50 | 42.04 | 8 | 10.36 |
| Virginia | 38 | 42.73 | 43 | 51.44 | 6 | 13.85 | 21 | 23.25 | 26 | 25.13 | 5 | 2.45 |
| **Totals** | 446 | 476.91 | 523 | 593.92** | 76 | 129.92 | 212 | 272.05 | 227 | 292.76*** | 63 | 89.91 |
| **Major** | | | | | | | | | | | | |
| Maritimes (01) | 7 | 8.86 | 7 | 7.30 | 1 | 0.42 | — | — | — | — | — | — |
| Maine (02) | 12 | 6.41 | 14 | 9.44 | 2 | 3.62 | 4 | 3.94 | 5 | 7.33 | 1 | 4.46** |
| S New Eng (03) | 31 | 54.88*** | 39 | 74.89*** | 7 | 21.50*** | 46 | 55.44 | 60 | 77.39* | 12 | 19.68* |
| LI-Hudson R (04) | 1 | 3.19 | 2 | 3.70 | 1 | 0.77 | — | — | — | — | — | — |
| Mid-Atl (05) | 104 | 103.23 | 121 | 120.48 | 18 | 21.73 | 33 | 42.76 | 41 | 61.09** | 8 | 17.32** |
| Mid-Atl C (06) | 95 | 115.71* | 112 | 126.49 | 16 | 19.33 | 55 | 52.16 | 72 | 79.15 | 15 | 27.19** |
| Lake Ont (08) | 38 | 42.15 | 50 | 60.45 | 10 | 20.09** | — | — | — | — | — | — |
| Lake Erie (09) | 11 | 5.89 | 14 | 9.71 | 3 | 3.76 | — | — | — | — | — | — |
| Tenn R (11) | 49 | 58.52 | 57 | 69.90 | 7 | 11.63 | 28 | 34.09 | 34 | 45.86* | 7 | 14.15** |
| Lake Mich (12) | 8 | 8.71 | 9 | 8.72 | 1 | 0.01 | — | — | — | — | — | — |
| Up Miss R (13) | 54 | 56.98 | 60 | 61.91 | 7 | 5.53 | 33 | 39.14 | 41 | 41.95 | 7 | 13.05* |
| **Totals** | 410 | 464.53** | 485 | 552.99** | 73 | 108.39 | 199 | 227.53 | 253 | 320.77*** | 50 | 95.85*** |
| **Minor** | | | | | | | | | | | | |
| Maine (021) | 12 | 6.41 | 14 | 9.44 | 2 | 3.62 | 4 | 3.94 | 5 | 7.33 | 1 | 4.46** |
| NH (031) | 5 | 6.93 | 6 | 6.98 | 1 | 0.00 | — | — | — | — | — | — |
| Mass (032) | 5 | 6.31 | 9 | 11.16 | 3 | 2.42 | 33 | 32.91 | 41 | 49.69 | 8 | 24.90*** |
| NY–LI (036) | — | — | — | — | — | — | 20 | 18.11 | 24 | 22.60 | 6 | 5.26 |
| NY (042) | 0 | 2.07 | 1 | 2.41 | 1 | 0.76 | — | — | — | — | — | — |
| Va (051) | 32 | 31.00 | 36 | 41.76 | 5 | 12.89** | 13 | 19.00 | 18 | 26.09 | 4 | 5.04 |
| NC (052) | 43 | 44.95 | 54 | 51.62 | 9 | 10.03 | 17 | 27.68** | 24 | 33.77 | 8 | 15.17* |
| Del (053) | 6 | 4.90 | 7 | 6.16 | 1 | 1.20 | — | — | — | — | — | — |
| Md (055) | 26 | 33.11 | 33 | 40.35 | 5 | 2.80 | 12 | 15.67 | 18 | 20.97 | 5 | 8.27 |
| NJ (063) | 63 | 73.40 | 76 | 84.12 | 12 | 10.30 | 36 | 29.72 | 46 | 42.47 | 10 | 13.19 |
| Va (064) | 9 | 12.81 | 11 | 13.89 | 2 | 1.52 | — | — | — | — | — | — |
| NY (081) | 35 | 33.94 | 45 | 56.61 | 9 | 23.07 | — | — | — | — | — | — |
| Tenn (113) | 46 | 56.50 | 55 | 67.36 | 7 | 13.98* | 24 | 26.93 | 33 | 37.53 | 7 | 8.73 |
| Mich (123) | 14 | 12.05 | 16 | 14.77 | 3 | 2.73 | — | — | — | — | — | — |
| Ill (131) | 15 | 14.26 | 16 | 14.07 | 2 | 1.26 | 9 | 18.22** | 12 | 22.05** | 2 | 4.01 |
| Tenn (133) | 50 | 47.24 | 58 | 57.30 | 7 | 9.49 | 26 | 16.81 | 31 | 23.79 | 6 | 5.68 |
| **Totals** | 361 | 385.88 | 437 | 478.00* | 69 | 96.07 | 194 | 208.99 | 252 | 286.28* | 57 | 94.71 |

*$\alpha < 0.1$; **$\alpha < 0.05$; ***$\alpha < 0.01$.

Table 15. *Summary of recovery and survival rates of black ducks (preseason bandings).*

| | Adult males | | Adult females | | Young males | | Young females | |
|---|---|---|---|---|---|---|---|---|
| Reference areas | Average recovery rate | Average survival rate | Average recovery rate | Average survival rate | Average recovery rate | Average survival rate | Average recovery rate | Average survival rate |
| **State** | | | | | | | | |
| Maine | 5.5 | 64.9 | 5.8 | 50.7 | 9.2 | 45.3 | 11.8 | 45.2 |
| Massachusetts | 4.0 | 74.5 | 7.1 | 36.1 | 9.6 | 58.2 | — | — |
| Michigan | 6.8 | 63.4 | — | — | 7.1 | 43.0 | — | — |
| New York | 7.0 | 59.6 | 5.0 | 53.4 | 12.8 | 44.8 | 11.6 | 44.4 |
| Ontario | 6.1 | 61.5 | 6.2 | 51.1 | 11.0 | 47.3 | 10.2 | 43.0 |
| Quebec | 5.7 | 64.8 | 5.5 | 60.3 | 11.1 | 38.8 | 11.3 | 41.5 |
| **Mean** | 5.8 | 64.8 | 5.9 | 50.3 | 10.1 | 46.2 | 11.2 | 43.5 |
| **Major** | | | | | | | | |
| Maritimes (01) | — | — | 6.3 | 43.8 | — | — | 11.8 | 36.3 |
| Lab &E Que (02) | 5.2 | 69.4 | — | — | — | — | — | — |
| S Que (04) | 6.4 | 66.0 | 5.9 | 60.0 | 12.4 | 35.6 | 12.4 | 43.2 |
| E Lake Ont (12) | 6.9 | 58.1 | 5.1 | 52.1 | 12.4 | 43.7 | 12.3 | 44.1 |
| W Lake Ont (13) | 6.6 | 62.3 | 5.8 | 48.3 | 12.3 | 44.5 | 11.4 | 58.9 |
| Up Gt Lakes (15) | 6.5 | 63.9 | 6.4 | 49.9* | 9.6 | 50.3 | — | — |
| W Lake Erie (16) | 7.6 | 57.5* | — | — | — | — | — | — |
| **Mean** | 6.5 | 62.8 | 5.9 | 50.8 | 11.7 | 43.5 | 12.0 | 45.6 |
| **Minor** | | | | | | | | |
| Quebec (041) | 6.3 | 67.4 | 5.9 | 60.0 | 12.4 | 35.3 | 12.4 | 43.2 |
| Massachusetts (081) | — | — | 4.5 | 52.4 | — | — | 7.4 | 35.2 |
| New York (122) | 7.3 | 57.0 | 5.0 | 53.0 | 12.2 | 41.5 | 11.4 | 44.3 |
| Ontario (131) | 6.8 | 59.3 | — | — | 11.0 | 41.4 | — | — |
| Ontario (151) | 5.9 | 69.2 | — | — | 9.4 | 75.6 | — | — |
| **Mean** | 6.6 | 63.2 | 5.1 | 55.1 | 11.3 | 48.4 | 10.4 | 40.9 |

* Adult and young banding data pooled.

Table 16. *Summary of recovery and survival rates of black ducks (winter bandings).*

| | Adult males | | Adult females | |
|---|---|---|---|---|
| Reference areas | average recovery rate | average survival rate | average recovery rate | average survival rate |
| **State** | | | | |
| Atlantic Flyway: | | | | |
| Delaware | 3.8 | 72.8 | 3.8 | 63.4 |
| Maine | 6.0 | 83.5 | 6.0 | 74.2 |
| Maryland | 3.9 | 70.1 | 3.4 | 54.4 |
| Massachusetts | 2.8 | 75.3 | 2.9 | 59.8 |
| New Jersey | 3.9 | 68.8 | 3.2 | 61.0 |
| New York | 4.5 | 66.9 | 4.2 | 55.2 |
| North Carolina | 2.8 | 68.5 | 3.3 | 50.6 |
| Virginia | 3.5 | 68.8 | 2.5 | 67.7 |
| **Mean** | 3.9 | 71.8 | 3.7 | 60.8 |

Table 16. *Continued.*

| Reference areas | Adult males average recovery rate | Adult males average survival rate | Adult females average recovery rate | Adult females average survival rate |
|---|---|---|---|---|
| Mississippi Flyway: | | | | |
| Illinois | 4.4 | 67.2 | 3.2 | 59.5 |
| Michigan | 4.3 | 68.9 | — | — |
| Ohio | 4.9 | 67.7 | 4.1 | 48.1 |
| Tennessee | 4.0 | 71.8 | 4.3 | 59.5 |
| **Mean** | 4.4 | 68.9 | 3.9 | 55.7 |
| **Major** | | | | |
| Atlantic Flyway: | | | | |
| Maritimes (01) | 3.3 | 55.4 | — | — |
| Maine (02) | 6.2 | 83.5 | 6.0 | 74.1 |
| S New Eng (03) | 2.2 | 78.4 | 3.2 | 60.2 |
| W LI-Hudson R (04) | 1.3 | 73.8 | — | — |
| Mid-Atl (05) | 3.6 | 67.5 | 3.3 | 60.0 |
| Mid-Atl C (06) | 3.8 | 67.6 | 3.1 | 61.6 |
| Lake Ont (08) | 6.4 | 62.9 | — | — |
| **Mean** | 3.8 | 69.9 | 3.9 | 64.0 |
| Mississippi Flyway: | | | | |
| Lake Erie (09) | 4.3 | 64.0 | — | — |
| Tenn R (11) | 4.3 | 68.5 | 4.4 | 63.4 |
| Lake Mich (12) | 4.8 | 68.7 | — | — |
| Up Miss R (13) | 4.3 | 71.0 | 4.2 | 55.3 |
| **Mean** | 4.4 | 68.0 | 4.3 | 59.3 |
| **Minor** | | | | |
| Atlantic Flyway: | | | | |
| Maine (021) | 6.2 | 83.5 | 6.0 | 74.2 |
| NH (031) | 8.7 | 60.4 | — | — |
| Mass(032) | 1.9 | 80.7 | 3.0 | 62.6 |
| NY-LI (036) | — | — | 4.0 | 57.9 |
| NY (042) | 1.4 | 69.9 | — | — |
| Va (051) | 4.0 | 78.4 | 2.7 | 66.0 |
| NC (052) | 2.8 | 69.6 | 3.3 | 53.9 |
| Del (053) | 3.6 | 68.5 | — | — |
| Md (055) | 3.9 | 69.0 | 2.8 | 62.7 |
| NJ (063) | 3.8 | 69.2 | 3.3 | 61.0 |
| Va (064) | 2.0 | 77.1 | — | — |
| NY (081) | 6.5 | 63.3 | — | — |
| **Mean** | 4.1 | 70.9 | 3.6 | 62.6 |
| Mississippi Flyway: | | | | |
| Tenn (113) | 4.5 | 67.8 | 4.8 | 60.0 |
| Mich (123) | 3.9 | 68.7 | — | — |
| Ill (131) | 4.4 | 67.2 | 3.2 | 59.5 |
| Tenn (133) | 3.7 | 72.8 | 4.2 | 59.0 |
| **Mean** | 4.1 | 69.1 | 4.1 | 59.5 |

al. 1978:180) was run on each data set that fit a Brownie or an Estimate Model. The $z$ statistic is asymptotically normal with mean 0 and variance 1 under the null hypothesis that there is no difference in annual recovery rates or in annual survival rates between areas or over time. The text results are shown in Appendix Tables H through K for "between areas" tests. Test for temporal differences in the two parameters are less extensive and are provided in the text.

## *Geographic Variation in Recovery Rates and Survival Rates*

Each $z$ test consisted of a comparison either of annual recovery rates or annual survival rates by age–sex class between pairs of geographic areas, e.g., adult male survival rates in Ontario were compared with adult male survival rates in New York. The data were represented in two ways: corresponding years of data were selected for each area, or different time periods (noncorresponding years) were used for comparing the recovery and survival parameters for each area. Many of the latter data sets contain partially overlapping years of data. I assumed that survival rates did not change significantly within a given area over a short span of time (10–15 years). Recovery rates are quite variable from year to year but fluctuate within a limited range of values (see Appendixes B–D). They are affected most by harvest regulations. Therefore, variation in recovery rates is to be expected between areas with different harvest regulations, different hunting pressure, or both. The $z$ tests were performed using data from states/provinces, major reference areas, and minor reference areas.

### Recovery Rates: Preseason Bandings, Corresponding Years (Appendix H)

*State/Province comparisons (Tables H-1, H-2).* Significant differences were found in three of seven tests for adult males. The highest adult male recovery rates were in New York, the lowest in Massachusetts. Young male recovery rates differed generally between states and provinces. New York and Quebec produced the highest recovery rates of young males. Michigan young black duck recovery rates were substantially lower than the others. Recovery rates of adult females were similar between areas. A highly significant difference was found between recovery rates of young females from Massachusetts and those from Quebec, the former being lower.

*Major reference area comparisons (Tables H-3, H-4).* Little variation was observed in adults of either sex. Only males in Labrador and Eastern Quebec(02), an area of low hunting pressure, showed a significant difference from another area (Eastern Lake Ontario(12), $P < 0.1$). The similarity of harvest regulations across eastern Canada may account, in part, for the similarity in recovery rates within each sex class. Young black duck recovery rates showed greater differences between major reference areas. However, those areas showing statistical significance generally related to comparisons of low hunting pressure areas to high hunting pressure areas.

*Minor reference area comparisons (Tables H-5, H-6).* The pattern for minor reference areas was similar to that of major reference areas. Few recovery rate differences were noted in adult black ducks, but young black duck recovery rates differed from area to area.

### Survival Rates: Preseason Bandings, Corresponding Years (Appendix H)

*State/Province comparisons (Tables H-7, H-8).* Only the Ontario versus Quebec adult male test showed significance ( $P< 0.1$). Quebec adult males apparently survived at a higher rate than Ontario adult males through the period 1964–1975. The reverse is noted for young males in Quebec. The survival rates of young and adult females from four areas are similar, but the failure to detect a statistically significant difference in the Massachusetts versus Quebec test for adult females probably relates to the poor survival estimate for Massachusetts (standard error = 12.06).

*Major reference area comparisons (Table H-9, H-10).* Survival rates of adult males in Eastern Lake Ontario(12) were significantly lower than those of other major reference areas. This agrees with the results from the provincial tests above. Statistically significant differences were noted in three tests of adult females, but in each case only 1 or 2 corresponding years of data were available. The observed variability between annual estimates could account for the test results.

Young males from Southern Quebec(04) had lower survival rates than young males from Eastern Lake Ontario(12) and Western Lake Ontario(13). Survival rates of young females were similar in all areas tested.

*Minor reference area comparisons (Tables H-11, H-12).* Adult male black ducks in Ontario(131) had survival rates significantly lower than adult male black ducks from Quebec(041) and Ontario(151). The New York(122) adult male survival rate was lower than that for Ontario (151). Only one adult female test was made. No statistical difference was noted between the survival rates of Quebec(041) and Massachusetts(081).

Young males from Ontario(151) showed a survival rate different from that of young in other minor reference

areas. Ontario(151) survival is poorly estimated (Table D-5), the survival estimate and its large sample standard error likely relate to the small sample size which produced in an imprecise estimate, and do not necessarily imply a greater survivability of young black ducks in Ontario(151).

The results obtained from these tests indicate that annual differences in recovery rates are general throughout the range of the black duck. The differences are greater and more widespread among young birds. Area differences in survival rates were detected less frequently. Survival rate differences tended to be masked at the state/province level, but were detected more often in the major and minor reference area comparisons. This is not unexpected since major reference areas, by definition, exhibit differences in distribution and recovery patterns. Unfortunately, most corresponding year comparisons were restricted to only a few years, usually three to five, but in some cases one. Results from such limited data can only be regarded as tentative.

### Recovery Rates: Preseason Bandings; Noncorresponding Years (Appendix I)

*State/Province (Tables I-1 through I-4).* Adult males showed significant variation in recovery rates. Generally, New York adult male recovery rates were the highest for both sexes while Massachusetts adult recovery rates were the lowest. Adult female recovery rates in New York during the early 1950's were exceptionally high (caused by an aberrant annual estimate for 1951; see Table I-2). The differences noted in the 1950–1954 tests relate to the exaggerated recovery rate estimate. The remaining New York adult female data sets were similar to recovery rates from other states and provinces and no significant differences were noted. Recovery rates of young birds of both sexes vary significantly between states and provinces. New York-banded young black ducks showed the highest recovery rates. Michigan, Maine and Massachusetts recovery rates for young were substantially lower than those of young birds in New York and Canada.

*Major reference area comparisons (Tables I-5, I-6).* No statistically significant differences in adult black duck recovery rates were noted between major reference areas. Recovery rates were consistent throughout the breeding range, generally varying by less than 1% between areas. Only the low recovery rate of young male black ducks from Upper Great Lakes(15) was significantly different from the recovery rates of young males in other major reference areas. This indicates low hunting pressure in western and northern Ontario.

*Minor reference area comparisons (Table I-7, I-8).* Results from these tests are similar to the major reference area tests except that New York(122) adult males showed a significantly higher ($P < 0.01$) recovery rate than Quebec(041) adult males, and local differences in the recovery rates of young birds in New York(122) were detected in the minor reference area tests that were not observable in the major reference area comparisons (Eastern Lake Ontario(12) vs. Western Lake Ontario(13)). Thus, regional differences within and between the two major reference areas were identified.

### Survival Rates: Preseason Bandings; Noncorresponding Years (Appendix I)

*State/Province (Tables I-9 through I-12).* Survival rate differences of adult males were noted in tests of New York data (1950–1953 and 1960–1967) versus Massachusetts data (1968–1971). New York data for the period 1960–1972 were not significantly different from other states and provinces. The Massachusetts survival rate estimate is unrealistically high, a reflection of limited, highly variable data (Table B-2). A marginal difference ($P < 0.1$) is indicated in both adult male and adult female survival rates in Ontario and Quebec. Maine adult female survival estimates are lower than Quebec's ($P < 0.05$). Quebec young males had the lowest survival rates tested. A significant difference was noted between Ontario and Quebec ($P < 0.05$), but not between New York and Quebec. Since the 1960's, young female survival rates have been similar in the states and provinces tested.

*Major reference area comparisons (Tables I-13, I-14).* Eastern Lake Ontario(12) adult male data produced the lowest survival rate; it was significantly lower than the survival rates of three other major reference areas tested (Western Lake Ontario(13), Upper Great Lakes(15), Southern Quebec(04)). The adult female survival rate in Southern Quebec(04) was significantly higher than survival rates in Maritimes(01), Western Lake Ontario(13), and Upper Great Lakes(15). However, the Southern Quebec(04) survival rate is based on small annual samples for only a 4-year period and it is poorly estimated. The Maritimes(01) survival rate also was derived from a small data set, but the standard error of the estimate was smaller than that of Southern Quebec(04) (SE = 3.99 vs. 5.10, respectively).

The survival rate of young males in Southern Quebec(04) was lower than that of all other young males tested ($P < 0.1$). Young females in Southern Quebec(04) also survived at a low rate but the difference was not significant compared to other areas.

*Minor reference area comparisons (Tables I-15, I-16).* The survival rate for Quebec(041) adult males was

significantly higher ($P < 0.01$) compared to New York (122) and Ontario(131). No survival rate differences were detected between minor reference areas for adult females or for young black ducks.

### Recovery Rates: Winter Bandings—Corresponding Years (Appendix J)

*State/Province (Tables J-1, J-2).* Significant differences between adult male recovery rates ($P < 0.05$, $P < 0.01$) were detected in several tests. Differences of one percent generally were highly significant. The lowest recovery rates were found in Massachusetts, the highest in Maine. Adult female recovery rates were lower than adult male recovery rates (indicative of lower prehunting season survival) and were similar in all areas tested, usually varying by less than 0.5%. No statistically significant recovery rate differences for females were noted between test areas.

### Survival Rates: Winter Bandings—Corresponding Years (Appendix J)

*State/Province (Tables J-3, J-4).* Survival rates were different in 5 of 24 adult male tests. Only one (Delaware vs. New York) was significant below the $P < 0.01$ level. Minor survival rate variations do occur in various states but the differences are small. Some data sets with widely divergent survival rate estimates failed to show significance indicating a large degree of variability in the annual survival estimates. No survival rate comparisons of adult females were statistically significant.

### Recovery Rates: Winter Bandings—Noncorresponding Years (Appendix K)

*State/Province comparisons (Tables K-1, K-2).* Recovery rates varied significantly in 20 of 37 tests between adult males by states and provinces. Twelve tests were significant at the $P < 0.01$ level. Twenty-one of 37 adult female tests were significant, 10 at the $P < 0.01$ level. Clearly, recovery rates of winter banded black ducks vary considerably by state/province.

*Major reference area comparisons (Tables K-3, K-4).* Results of the z tests by major reference areas enhanced the results of the state/province comparisons. They support more strongly the conclusion that recovery rates of winter banded black ducks are different throughout the wintering range. Although fewer tests of adult female recovery rates were possible by major reference areas, four of nine tests showed significant differences, three at the $P < 0.01$ level of significance.

*Minor reference area comparisons (Tables K-5, K-6).* Seventy-five percent (77) of 102 tests of adult male recovery rates by minor reference areas were significantly different, most at the $P < 0.01$ level. Results of adult female tests showed significance in 43% of all cases, but generally at the $P < 0.05$ significance level.

### Survival Rates: Winter Bandings—Noncorresponding Years (Appendix K)

*State comparisons (Tables K-7, K-8).* One of 37 tests of adult male survival rates was statistically significant (Ohio vs. Tennessee). The survival estimate for Maine is based on limited and highly variable banding data (Appendix Table E-3) which resulted in a finding of no significance, even in tests between areas with widely disparate survival estimates. However, based on the findings of earlier tests I believe small differences in adult male survival rates do occur, but are too small to be detected. Ten tests of adult female survival rates showed differences between states. Adult female winter bandings are fewer than adult male bandings and the survival estimates of adult females are measured with less precision. It is somewhat surprising then, that differences in adult male survival rates between states were not detected. Differential mortality rates on the various breeding grounds from which the wintering populations are derived may account in part for the significant differences in survival rates noted for adult females. However, the significant findings for adult females relate to comparisons of New Jersey adult female survival with extreme survival estimates for New York (low) and Virginia (high). Therefore, the statistical significance observed may relate primarily to the precision of the survival estimates tested rather than to large regional differences in survival.

*Major reference area comparisons (Table K-9, K-10).* Three of four statistically different survival rate estimates for adult males relate to the exceedingly high survival rate estimate for Maine(02). Otherwise, the results of major reference area tests agree closely with the state test results. Adult female tests showed no significant differences between major reference areas. This apparent difference compared with the state test results is explained by the importance of the New York and Virginia survival estimates in the state test results. However, for the major reference area tests New York state data is contained, in part, in New York(04)–western Long Island and the eastern half of upstate New York and in Southern New England(03)–eastern Long Island (see Figure 3). No tests could be run with the New York(04) data. Virginia state data were divided between Mid-Atlantic(05) and Mid-Atlantic Coastal(06). In the latter case, the inclusion of other Mid-Atlantic states data resulted in a lower survival estimate than the estimate derived from Virginia data alone and no significant results were noted.

*Minor reference area comparisons (Tables K-11, K-12).* Only 6 of 102 tests (this would be expected by chance alone) showed significant survival rate differences for adult males; none was significant below the $P < 0.1$ level. These findings agree closely with the results for state and major reference areas and indicate that only slight survival rate differences exist among wintering populations of adult male black ducks. Virginia bandings were associated with most of the statistically significant survival rate differences. Similar findings pertain to the data for adult females which support the results of tests in the two previous sections.

One rather obvious point of concern is the wide divergence of survival rate estimates for several states—in particular, the differences between data sets that compare Maine(021), New Hampshire(031), and Massachusetts(032) with other Atlantic coastal states. The estimates for the three data sets lack precision (Tables G-1, G-2, G-3, respectively). The high degree of variability in annual survival rates precludes a finding of significance in most cases where the data are used.

## *General Observations*

Recovery rate differences were detected less frequently by the tests comparing noncorresponding years. This reflects the likelihood that a small number of annual comparisons will be more variable than a larger number. However, the data do show recovery rate differences between areas, particularly between young birds, and reflect differences in hunting pressure. Conversely, survival rate differences between areas were observed more frequently among adults, particularly adult males. This is explained in part by the uniformly low survival estimates of young black ducks of both sexes rangewide.

Unfortunately, the preseason banding data for adults generally lack sufficient bandings to yield Brownie estimates of great precision. This is shown clearly by many entries in Appendixes H and I, in which recovery and survival rate differences are quite large (Column 4) yet the test statistic shows no significant difference. However, those data sets with the smallest standard errors (e.g., Eastern Lake Ontario(12) and Southern Quebec(04) adult males) as well as several data sets with greater variability in annual parameter estimates do support the conclusion that recovery rates and survival rates are dissimilar to varying degrees in the many states/provinces, major reference areas and minor reference areas tested.

Adult males and females showed significant differences in recovery rates throughout the winter range, although no differences were noted for females in tests comparing data of corresponding years.

Male survival rates generally showed few area differences. Where significant findings were noted, extremes in survival estimates were involved. However, the variability of annual survival estimates (Appendix Tables E, F, and G) probably masked many small geographic differences in survival; intuitively, some variation in survival would be expected. Wintering females showed substantial variation in survival geographically, but again, the comparisons involved extreme survival rate estimates. It does seem reasonable, though, to expect small geographic differences in the survival rates of females.

## *Adequacy of Banded Samples*

No adequate preseason banding samples for any age–sex group exist for the far northern portions of the black duck's range. Also, banded samples in southern Canada and the United States are inadequate for adults. The best preseason data sets are those for New York(122), Quebec(041), Eastern Lake Ontario(12), and Ontario, yet these data sets contain minimal numbers of adult bandings. The problem appears to be insurmountable under current economic conditions and resource priorities. The low density and brood dispersal of adult birds on the breeding grounds necessitate major expenditures of manpower and equipment to conduct a successful banding program. Unless current efforts by Canadian and provincial wildlife departments to identify promising new banding sites for adults are fruitful, attention should be given to a banding program designed to monitor only black duck recovery rates and distribution. Major banding efforts would then be restricted to specific, geographically limited research efforts.

Winter banding data sets are adequate in several coastal states. However, despite large sample sizes some data sets (particularly those of Massachusetts and New Jersey) did not fit the Estimate models in their entirety. Data were sacrificed to obtain a span of years that would fit an Estimate model. However, recent winter bandings are adequate in Massachusetts, New York, New Jersey, Maryland, Virginia, North Carolina, Tennessee, Prince Edward Island, and Nova Scotia. Increased banding effort associated with the black duck reward band program initiated in January 1978 has improved the level of banding in other states since this study was initiated. Increased banding is needed in the northern Mississippi Flyway states if that segment of the population is to be monitored properly. However, the vagaries of weather place a more severe limitation on the success of banding efforts in the midwestern states.

Table 17. *Summary of the results of testing the hypothesis that young and adult black ducks have similar recovery and survival rates (preseason bandings).*

| Reference areas | Males | | Females | |
|---|---|---|---|---|
| | df | $\chi^{2a}$ | df | $\chi^{2a}$ |
| **State** | | | | |
| Maine | 6 | 26.10*** | 12 | 62.06*** |
| Massachusetts | 8 | 37.42*** | — | — |
| Michigan | 14 | 21.54* | — | — |
| New York | 16 | 123.36*** | 14 | 64.24*** |
| Ontario | 20 | 179.98*** | 18 | 94.16*** |
| Quebec | 26 | 216.51*** | 8 | 70.41*** |
| **Totals** | 90 | 604.91*** | 52 | 209.87*** |
| **Major** | | | | |
| Maritimes (01) | — | — | 10 | 37.92*** |
| Lab & E Que (02) | 6 | 18.26*** | — | — |
| S Que (04) | 16 | 137.80*** | 8 | 45.60*** |
| E Lake Ont (12) | 26 | 184.12*** | 24 | 149.03*** |
| W Lake Ont (13) | 16 | 119.24*** | 8 | 22.72*** |
| Up Gt Lakes (15) | 10 | 20.22** | — | — |
| **Totals** | 74 | 479.64*** | 50 | 255.27*** |
| **Minor** | | | | |
| Ontario (041) | 16 | 148.68*** | 8 | 45.60 |
| New York (122) | 22 | 125.30*** | 14 | 51.34*** |
| Ontario (131) | 16 | 75.81*** | — | — |
| Ontario (151) | 10 | 19.52** | — | — |
| **Totals** | 64 | 369.31*** | 22 | 96.94*** |

[a] Specifically, this is a contingency chi-square test of $H_0$ versus $H_1$.
*$\alpha < 0.1$; **$\alpha < 0.05$; ***$\alpha < 0.01$.

## *Age- and Sex-specific Population Parameters*

The age and sex structure of a population is of fundamental importance to the study of population dynamics. Mortality and natality generally differ greatly with age, whereas natality is influenced by the sex structure of the population because the fecundity of a population is a function of the number of females in the population (Ricklefs 1973:445). Anderson (1975:15) identified the need to evaluate differences in mallard age and sex parameters using average annual estimates rather than annual estimates because of the large sampling errors usually associated with annual estimates. The same problem exists in relation to black duck age- and sex-specific population parameters.

### Locals Versus Immatures

Bandings of locals generally were not numerically sufficient or temporally and geographically distributed to warrant analysis. However, Anderson's (1975:16) findings with respect to local and immature mallards are pertinent. He examined samples of 31,000 males and 25,000 females under the hypothesis that 1st-year recovery rates are the same for the two age classes when banded in the same area and year. A one-tailed $z$ test failed to reject the null hypothesis ($z = 0.45$ for males, $z = 0.15$ for females). The difference in average recovery rates was 0.0023 for males (0.1127—local males vs. 0.1150—immature males) and 0.0016 for females (0.0950—local females vs. 0.0966—immature females). Anderson concluded that locals and immatures have similar recovery and survival processes. I assumed that the same relationship holds for geographically and temporally related local and immature black ducks. Accordingly, I have treated all local and immature birds as "young" in this study.

## Age-specific Parameters

A chi-square contingency test of Model $H_0$ versus $H_1$ (Brownie and Robson 1974; Brownie et al. 1978:88) was used to test the assumption that annual recovery and survival rates are independent of age (see Table 8). The test results (Table 17) indicate that significant differences exist between young and adult male and female recovery and survival rates. $Z$ test statistics also were used to compare annual recovery and survival estimates. They produced equally strong results with respect to recovery rates for males and females (Table 18) and with respect to survival rates for males, but the rejection level with respect to female survival rates (Table 19) is less strong. Although the composite $z$ test results for state/province and minor reference area bandings of females are significant, no data sets other than those associated with Quebec show a significant difference in young and adult female survival rates. The failure of the $z$ test to strongly reject the null hypothesis probably relates to the small number of adult female bandings annually, which produces annual survival estimates that vary substantially. Anderson (1975:18) expressed surprise that age-specific differences in mallard females could be detected with the paucity of female banding data available to him. Therefore, the results shown here are not unexpected. A sign test was computed on survival estimates of the two age groups. The difference was significant for state/provincial bandings ($P < 0.03$), but was nonsignificant for major and minor reference areas. My conclusion, based on the showing of a significant difference in the Quebec data, is that a difference does exist between young and adult female recovery and survival rates, but that differences in survival rates are difficult to detect because of insufficient data and the associated low power of the tests.

Brownie et al. (1978:80) provide a model to test the age-dependence of subadults (yearlings). Because only two age classes are identified in the banding process, no parameter estimates are possible for subadults. However, within the "adult" age class a proportion of subadults is present. Model $H_3$ tests for differences in recovery and survival rates of subadults based on the assumptions of

Table 18. *Results of testing the hypothesis that young and adult black ducks have similar mean recovery rates (preseason bandings).*

| Reference areas | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|
| | Young | Adults | Difference | $z$ Value | Young | Adults | Difference | $z$ Value |
| **State/Province** | | | | | | | | |
| Maine | 9.17 | 5.51 | 3.66 | 3.757*** | 11.58 | 6.60 | 4.98 | 5.255*** |
| Massachusetts | 9.58 | 4.01 | 5.57 | 5.295*** | — | — | — | — |
| Michigan | 7.06 | 6.75 | 0.31 | 0.330 | — | — | — | — |
| New York | 12.81 | 7.00 | 5.81 | 11.099*** | 10.90 | 5.01 | 5.90 | 6.341*** |
| Ontario | 11.71 | 6.65 | 5.06 | 10.163*** | 10.20 | 6.20 | 4.00 | 6.764*** |
| Quebec | 11.11 | 5.69 | 5.42 | 16.585*** | 11.30 | 5.52 | 5.78 | 1.751* |
| Composite test statistic | | | | 16.585*** | | | | 9.422*** |
| **Major** | | | | | | | | |
| Maritimes (01 | — | — | — | — | 11.82 | 6.20 | 5.62 | 5.658*** |
| Lab & E Que (02 | 6.08 | 5.15 | 0.93 | 0.543 | — | — | — | — |
| S Que (04 | 12.41 | 6.43 | 5.48 | 8.377*** | 12.43 | 5.88 | 6.56 | 5.882*** |
| E Lake Ont (12 | 12.36 | 6.94 | 5.41 | 11.847*** | 12.23 | 5.10 | 7.13 | 9.666*** |
| W Lake Ont (13 | 12.29 | 6.64 | 5.65 | 8.989*** | 11.37 | 5.89 | 5.48 | 5.362*** |
| Up Gt Lakes (15 | 9.57 | 6.47 | 3.10 | 3.289*** | — | — | — | — |
| Composite test statistic | | | | 14.778*** | | | | 13.284*** |
| **Minor** | | | | | | | | |
| Quebec (041) | 12.41 | 6.32 | 6.08 | 8.918*** | 12.43 | 5.88 | 6.56 | 5.882*** |
| New York (122) | 12.30 | 7.31 | 4.98 | 4.100*** | 11.40 | 5.01 | 6.39 | 7.409*** |
| Ontario (131) | 11.01 | 6.79 | 4.22 | 5.850*** | — | — | — | — |
| Composite test statistic | | | | 10.893*** | | | | 9.398*** |

$^*\alpha < 0.1$; $^{***}\alpha < 0.01$.

Table 19. *Results of testing the hypothesis that young and adult black ducks have similar mean survival rates (preseason bandings).*

| | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|
| Reference areas | Young | Adults | Difference | *z* Value | Young | Adults | Difference | *z* Value |
| **State/Province** | | | | | | | | |
| Maine | 45.26 | 64.88 | −19.62 | −2.733*** | 45.24 | 50.68 | −5.44 | −0.799 |
| Massachusetts | 58.16 | 74.53 | −16.37 | −1.208 | — | — | — | — |
| Michigan | 43.03 | 63.35 | −20.32 | −0.966 | — | — | — | — |
| New York | 44.84 | 59.56 | −14.72 | −5.101*** | 44.39 | 53.38 | −8.99 | −0.798 |
| Ontario | 47.48 | 61.13 | −13.65 | −4.533*** | 43.00 | 51.10 | −8.10 | −1.279 |
| Quebec | 38.77 | 64.81 | −26.04 | −7.887*** | 41.45 | 60.33 | −18.88 | −2.314** |
| Composite test statistic | | | | −9.156*** | | | | −2.325** |
| **Major** | | | | | | | | |
| Maritimes (01) | — | — | — | — | 36.07 | 43.48 | −7.41 | −1.185 |
| Lab & E Que (02) | 41.36 | 69.38 | −28.02 | −2.280** | — | — | — | — |
| S Que (04) | 35.56 | 66.02 | −30.46 | −7.341*** | 43.20 | 60.04 | −16.84 | −1.895* |
| E Lake Ont (12) | 43.61 | 58.07 | −14.46 | −4.927*** | 44.06 | 52.10 | −8.04 | −0.916 |
| W Lake Ont (13) | 44.49 | 62.27 | −17.78 | −4.102*** | 58.87 | 48.27 | +10.60 | +0.898 |
| Up Gt Lakes (15) | 50.33 | 63.88 | −13.55 | −2.017** | — | — | — | — |
| Composite test statistic | | | | −9.243*** | | | | −1.549 |
| **Minor** | | | | | | | | |
| Quebec (041) | 35.25 | 67.43 | −32.18 | −7.818*** | 43.20 | 60.04 | −16.84 | −1.895* |
| New York (122) | 41.52 | 56.92 | −15.40 | −2.511** | 44.30 | 52.93 | −8.63 | −0.729 |
| Ontario (131) | 41.36 | 59.31 | −17.95 | | | | — | — |
| Composite test statistic | | | | −8.477*** | | | | −1.855* |

$^{*}\alpha < 0.1$; $^{**}\alpha < 0.05$; $^{***}\alpha < 0.01$.

(1) age-dependent recovery and survival rates for the first 2 years of life, and (2) year specific annual recovery and survival rates.

The test is inappropriate for data sets which do not fit Model $H_3$ (Maine and Ontario males). Test results are shown in Table 20 (likelihood ratio test; Brownie et al. 1978:87). No significant chi-square values were noted for males. For females the two age-class model was rejected only in Southern Quebec(04) and Quebec(041) which in this case are represented by the same data set. The test results were significant at the 5% level. Overall the evidence that subadults have different recovery and survival rates is weak. Anderson (1975:18) suggests that incorrect aging of young birds as adults at the time of banding could cause the results observed here.

### Sex-specific Parameters

The sex-specificity of recovery and survival rates are of fundamental importance to an understanding of the black duck population. The development of the simulation models in the following section of this study make use of the findings presented here.

### Adults

Maine and Ontario each showed a significant difference in adult male and female survival rates (Table 21). The low number of preseason bandings, particularly of adult birds, produced quite variable annual survival estimates which reduced the power of the *z* tests to detect differences. The test results from winter bandings (Table 22) are more convincing. Strong rejection of the null hypothesis that adult male and female survival rates are similar is demonstrated by the composite test statistics for all reference area groups. I believe similar differences exist within preseason-banded populations also, but the survival estimates lack sufficient precision to detect them. My conclusion is that average annual survival rates of adult males are higher than those of adult females.

Table 20. *Results of testing the hypothesis that survival and recovery rates of young black ducks are age-dependent for only the 1st year.*

| | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|
| | Fit of $H_3$ | | $H_2$ vs. $H_3$ | | Fit of $H_3$ | | $H_2$ vs. $H_3$ | |
| Reference areas | df | $X^2$ | df | $X^2$ | df | $X^2$ | df | $X^2$ |
| **State/Province** | | | | | | | | |
| Maine | 10 | 26.47*** | — | — | 9 | 7.24 | 6 | 8.505 |
| Massachusetts | 9 | 10.34 | 4 | 2.219 | — | — | — | — |
| Michigan | 16 | 9.20 | 7 | 4.082 | — | — | — | — |
| New York | 65 | 78.24 | — | — | 28 | 22.74 | 7 | 11.503 |
| Ontario | 70 | 85.97* | — | — | 28 | 27.03 | 9 | 7.788 |
| Quebec | 50 | 49.42 | 13 | 13.104 | 19 | 7.47 | 4 | 6.263 |
| **Totals** | | | 50 | 53.749 | | | 26 | 34.059 |
| **Major** | | | | | | | | |
| Maritimes (01) | — | — | — | — | 2 | 3.70 | 5 | 5.440 |
| Lab & E Que (02) | 4 | 2.61 | 3 | 1.544 | — | — | — | — |
| S Que (04) | 22 | 24.55 | 8 | 13.870 | 12 | 11.58 | 4 | 9.594** |
| E Lake Ont (12) | 66 | 60.46 | 13 | 17.433 | 35 | 40.73 | 12 | 12.523 |
| W Lake Ont (13) | 32 | 37.09 | 8 | 6.055 | — | — | — | — |
| Up Gt Lakes (15) | 25 | 26.40 | 5 | 2.936 | — | — | — | — |
| **Totals** | | | 37 | 41.838 | | | 21 | 27.557 |
| **Minor** | | | | | | | | |
| Quebec (041) | 30 | 27.41 | 8 | 14.468 | 12 | 11.58 | 4 | 9.594** |
| New York (122) | 48 | 44.89 | 11 | 11.772 | 20 | 20.31 | 7 | 11.805 |
| Ontario (131) | 32 | 40.89* | 8 | 8.273 | — | — | — | — |
| Ontario (151) | 12 | 12.93 | 5 | 5.607 | — | — | — | — |
| **Totals** | | | 32 | 40.120 | | | 11 | 21.400** |

*$\alpha < 0.1$; **$\alpha < 0.05$; ***$\alpha < 0.01$.

Preseason adult recovery rates show a significant difference at the 5% probability level for bandings in the New York–Ontario border region (Table 23). Differences in the major and minor reference area tests, related primarily to bandings in the New York–Ontario region, suggest a higher recovery rate for adult males. Recovery rates for winter-banded birds (Table 24) also show evidence of a difference between adult male and female recovery rates. These differences reflect a higher rate of summer mortality experienced by adult females rather than greater hunting pressure on adult males. My conclusion is that adult males do have higher recovery rates than adult females.

### Young

The test results for young birds show no evidence that the null hypothesis that young male and female black ducks have similar mean survival rates can be rejected (Table 21). Anderson (1975:22) found similar results for the mallard. In that study only 2 of 18 reference areas indicated that the null hypothesis should be rejected. Anderson (1975:79) attributed the failure to detect a difference in young male and female survival rates to small sample size and a lack of banded young birds in some reference areas. Bandings of young black ducks have averaged between 500 and 600 per year for most data sets, a banding level not substantially different from that of young mallards. Also, northern portions of the black duck's breeding range are poorly represented by bandings for either age class so that no estimates of survival and recovery rates are available. Adult black duck bandings, which are necessary to permit the estimation of recovery and survival rates for young (Brownie et al. 1978:112) are insufficient in many of the data sets with adequate bandings of young birds. Survival rate estimates of young and adult birds are correlated, therefore

Table 21. *Results of testing the hypothesis that male and female black ducks have similar mean survival rates (preseason bandings).*

| | Adults | | | | Young | | | |
|---|---|---|---|---|---|---|---|---|
| Reference areas | Males | Females | Difference | $z$ Value | Males | Females | Difference | $z$ Value |
| **State/Province** | | | | | | | | |
| Maine | 64.88 | 50.68 | 14.20 | 3.528*** | 45.26 | 45.24 | 0.20 | 0.002 |
| New York | 59.56 | 53.38 | 6.18 | 0.674 | 44.84 | 44.39 | 0.45 | 0.062 |
| Ontario | 61.50 | 51.10 | 10.40 | 1.918* | 47.34 | 43.01 | −4.34 | −0.942 |
| Quebec | 64.81 | 60.33 | 4.48 | 0.879 | 38.77 | 41.45 | −2.68 | −0.373 |
| Composite test statistic | | | | 3.499** | | | | −0.437 |
| **Major** | | | | | | | | |
| S Que (04) | 66.02 | 60.04 | 5.98 | 1.067 | 35.56 | 43.20 | −7.64 | −0.943 |
| E Lake Ont (12) | 58.07 | 52.10 | 5.97 | 0.827 | 43.61 | 44.06 | −0.45 | −0.077 |
| Composite test statistic | | | | 1.340 | | | | −0.721 |
| **Minor** | | | | | | | | |
| Quebec (041) | 67.43 | 60.04 | 7.39 | 1.319 | 35.25 | 43.20 | −7.95 | −0.983 |
| New York (122) | 56.92 | 52.93 | 3.99 | 0.370 | 41.52 | 44.30 | −2.78 | −0.357 |
| Composite test statistic | | | | 1.194 | | | | −0.947 |

**$\alpha < 0.05$; ***$\alpha < 0.01$.

the precision of the parameter estimates for young birds is affected by the precision of the preseason adult parameter estimates. If a difference between young male and female survival rates does exist, either the data do not yield estimates of sufficient precision to detect it, or parts of the breeding range where survival differences may exist are not represented by banded samples. Anderson (1975:20) suggests that a difference of 2 to 3% between young male and female survival is likely based on the results observed for adult males and females. Factors responsible for the differential mortality of young females might be most pronounced in spring and fall migration and on the wintering grounds.

The Maine data set showed a significant difference ($P < 0.01$) in recovery rates of young males and females (Table 23), but the composite z statistics were nonsignificant in all test groups. The failure to detect recovery rate differences between young males and females is related in part to sample size, variability, and distribution. However, intensive hunting pressure on the breeding grounds as evidenced by the high recovery rates probably eliminates recovery rate differences between the sexes that otherwise might occur. Anderson (1975:20; Table 13) found that young male mallards have significantly higher recovery rates than young female mallards. North and South Dakota were the only primary breeding grounds tested that showed similarities in young male and female recovery rates. Overall, the recovery rates of young mallards on the breeding grounds are slightly lower than those of young black ducks.

## *Estimates of Average Survival Rates*

The difficulty confronted when estimating a continental average annual survival estimate for each age and sex class relates to three factors: (1) large sampling variation, (2) lack of banded samples in northern populations (and insufficient adult bandings generally), and (3) the lack of an acceptable way to pool the estimates across areas (Anderson 1975:21). No accurate estimates of population size are available for black ducks although indirect estimates of average population size for a 14-year period have been developed recently (Pospahala et al. 1971; Spencer 1980:7); annual population estimates are unavailable. Taking into account the inadequacies of the banding data, a simple average annual preseason survival rate for each age and sex class (over areas and years) was computed by using average annual survival rate data for state reference areas presented in Appendix B.

The mean survival rates of the black duck in eastern Northern America are:

Table 22. *Summary of estimates of average survival in male and female black ducks banded as adults (winter bandings).*

| Reference areas | Mean Survival Adult males | Mean Survival Adult females | Difference | $z$ Value |
|---|---|---|---|---|
| **State** | | | | |
| Delaware (021) | 68.7 | 63.4 | 5.30 | .410 |
| Illinois (034) | 67.2 | 59.5 | 7.7 | 1.585 |
| Maine (044) | 83.5 | 69.3 | 14.3 | 0.619 |
| Maryland (046) | 70.1 | 54.4 | 15.7 | 3.476*** |
| Massachusetts (047) | 75.3 | 59.7 | 15.6 | 1.816* |
| New Jersey (059) | 68.8 | 60.9 | 7.9 | 3.553*** |
| New York (061) | 65.3 | 55.2 | 10.1 | 2.332** |
| North Carolina (063) | 68.5 | 50.6 | 17.9 | 2.168** |
| Ohio (066) | 67.7 | 48.1 | 19.6 | 1.632 |
| Tennessee (082) | 71.8 | 59.4 | 12.2 | 3.448*** |
| Virginia (088) | 66.8 | 67.7 | −0.9 | −0.119 |
| Composite test statistic | | | | 6.308*** |
| **Major** | | | | |
| Maine (021) | 83.5 | 69.3 | 14.3 | 0.620 |
| Massachusetts (032) | 78.6 | 62.4 | 16.2 | 1.230 |
| Virginia (051) | 71.6 | 66.0 | 5.6 | 0.611 |
| North Carolina (052) | 69.5 | 53.9 | 15.7 | 3.740*** |
| Maryland (055) | 69.0 | 59.3 | 9.7 | 2.260** |
| New Jersey (063) | 69.2 | 61.0 | 8.2 | 3.630*** |
| Tennessee (113) | 64.2 | 60.0 | 4.2 | 0.728 |
| Illinois (131) | 67.2 | 59.5 | 7.7 | 1.590 |
| Composite test statistic | | | | 5.041*** |
| **Minor** | | | | |
| Maine (020) | 83.5 | 69.3 | 14.3 | 0.619 |
| S New England (030) | 77.4 | 60.2 | 11.4 | 1.519 |
| Mid-Atlantic (050) | 67.5 | 60.0 | 7.4 | 1.546 |
| Mid-Atlantic Coastal (060) | 67.6 | 59.2 | 8.5 | 1.876* |
| Tennessee River (110) | 68.5 | 63.4 | 5.1 | 0.763 |
| Upper Mississippi R (130) | 70.9 | 55.3 | 15.7 | 3.541*** |
| Composite test statistic | | | | 4.027*** |

*$\alpha < 0.1$; **$\alpha < 0.05$; ***$\alpha < 0.01$.

| *Age–sex group* | *Mean survival %* |
|---|---|
| Adult male | 63 |
| Adult female | 56 |
| Young male | 43 |
| Young female | 43 |

The continental survival estimates for adult male and female black ducks are similar to those derived by Anderson (1975:22) for adult male and female mallards. However, the average survival rate for young black ducks is 7% lower than Anderson's estimate for young mallards (50%).

Computation of a continental average survival rate using data from other reference area groups (major, minor) or from pooling large geographic areas—i.e., the Lake states, northeastern states, the Maritimes—yields survival rate values above and below those shown above for young birds. In no case does the estimate for young birds exceed 45–46%. The lower estimates indicate that young black ducks generally have a lower survival rate than young mallards.

Table 23. *Results of testing the hypothesis that male and female black ducks have similar mean recovery rates (preseason bandings).*

| Reference areas | Adults Males | Adults Females | Adults Difference | Adults $z$ Value | Young Males | Young Females | Young Difference | Young $z$ Value |
|---|---|---|---|---|---|---|---|---|
| **State/Province** | | | | | | | | |
| Maine | 5.52 | 5.80 | 0.30 | −0.261 | 9.17 | 11.58 | −2.41 | −2.751*** |
| New York | 7.00 | 5.01 | 1.99 | 2.386** | 12.81 | 10.90 | 1.91 | 0.558 |
| Ontario | 6.61 | 6.20 | 0.10 | −0.253* | 11.00 | 10.20 | 0.78 | 1.503** |
| Quebec | 5.69 | 5.51 | 0.18 | 0.242 | 11.11 | 11.30 | −0.19 | −0.217 |
| Composite test statistic | | | | 1.466 | | | | −0.317 |
| **Major** | | | | | | | | |
| S Que (04) | 6.43 | 5.88 | 0.55 | 0.702 | 12.41 | 12.43 | −0.02 | −0.023 |
| E Lake Ont (12) | 6.91 | 5.10 | 1.81 | 2.538** | 12.52 | 12.23 | 0.29 | 0.259 |
| Composite test statistic | | | | 2.291** | | | | 0.199 |
| **Minor** | | | | | | | | |
| Quebec (041) | 6.32 | 5.88 | 0.45 | 0.571 | 12.41 | 12.43 | −0.02 | −0.023 |
| New York (122) | 7.31 | 5.01 | 2.30 | 2.521** | 12.30 | 11.40 | 0.89 | 1.257 |
| Composite test statistic | | | | 2.186** | | | | 0.873 |

*$\alpha$ <0.1; **$\alpha$ < 0.05; ***$\alpha$ < 0.01.

The mean survival rates of winter banded black ducks were derived from averages of all reference areas of banding:

| *Age–sex group* | *Mean survival* |
|---|---|
| Adult male | 70.0 |
| Adult female | 61.1 |

Individual winter reference area survival estimates are compared to preseason survival estimates below.

Survival estimates for wintering populations are more numerous and almost always derived from substantially larger data sets than are preseason estimates (i.e., years of banding and number of bandings annually). However, black duck winter survival estimates are not measured as precisely as the preseason survival estimates. This relates to the higher recovery rate of preseason banded birds which more than compensates for the smaller preseason banded samples.

## *Comparison of Preseason Banded and Winter Banded Survival Estimates*

Theoretically, the survival of preseason and winter banded populations should be similar. Winter survival estimates, like preseason survival estimates, are based on a calendar year and should agree closely with the preseason survival estimates of those breeding areas supplying significant numbers of wintering birds to a particular wintering area. The results of the z tests to compare survival rates between geographic areas (Appendixes H–J) indicate that only small differences, if any, exist between different areas, therefore the mixing of several different breeding ground populations in a given wintering area should not violate the hypothesis of similar preseason and winter survival estimates for related breeding grounds and wintering areas.

Table 25 gives the results of z tests comparing preseason and winter survival estimates for related geographic areas. Only two tests, Maine versus Maine and Western Lake Erie(16) versus Lake Erie(09) (preseason survival estimate vs. winter survival estimate) showed statistically significant differences ($P < 0.1$). In both cases, abnormalities in the survival estimates are evident. The winter survival estimate for Maine males (83.5%) is unrealistically high. The standard error of the estimate is large also (7.5%), but a difference was detected compared to the preseason adult male survival estimate of 64.9% (SE = 2.6%). The winter survival estimate for females also is high (74.2%), but because the standard error of the estimate is so great (18.8%) no difference

Table 24. *Results of the hypothesis that male and female black ducks have similar mean recovery rates (winter bandings).*

| Reference areas | Mean Recovery Adult males | Adult females | Difference | $z$ Value |
|---|---|---|---|---|
| **State** | | | | |
| Delaware (021) | 3.8 | 3.8 | — | −0.049 |
| Illinois (034) | 4.4 | 3.2 | 1.3 | 2.870*** |
| Maine (044) | 6.0 | 6.0 | 0.1 | 0.056 |
| Maryland (046) | 3.9 | 3.4 | 0.5 | 1.067 |
| Massachusetts (047) | 2.8 | 2.9 | −0.2 | −0.573 |
| New Jersey (059) | 3.9 | 3.2 | 0.7 | 2.798*** |
| New York (061) | 4.5 | 4.2 | 0.3 | 0.229 |
| North Carolina (063) | 2.8 | 3.3 | −0.6 | −1.369 |
| Ohio (066) | 4.9 | 4.1 | 0.9 | 1.011 |
| Tennessee (082) | 4.1 | 4.3 | −0.3 | −0.938 |
| Virginia (088) | 3.5 | 2.5 | 0.9 | 2.284** |
| Composite test statistic | | | | 2.226** |
| **Major** | | | | |
| Maine (021) | 6.2 | 6.0 | 0.2 | 0.188 |
| S New England (030) | 2.2 | 3.2 | −1.0 | −3.511*** |
| Mid-Atlantic (050) | 3.6 | 3.3 | 0.3 | 1.384 |
| Mid-Atlantic Coastal (060) | 3.8 | 3.1 | 0.7 | 3.373*** |
| Tennessee River (110) | 4.3 | 4.4 | −0.1 | −0.179 |
| Upper Mississippi River (13) | 4.3 | 4.2 | 0.1 | 0.186 |
| Composite test statistic | | | | 0.588 |
| **Minor** | | | | |
| Maine (021) | 6.1 | 6.0 | 0.1 | 0.188 |
| Massachusetts (032) | 2.9 | 3.0 | −0.1 | −0.156 |
| Virginia (051) | 4.0 | 2.7 | 1.2 | 2.410** |
| North Carolina (052) | 2.8 | 3.3 | −0.6 | −1.475 |
| Maryland (055) | 3.9 | 3.5 | 0.4 | 0.785 |
| New Jersey (056) | 3.8 | 3.3 | 0.6 | 2.489** |
| Tennessee (113) | 4.5 | 4.8 | −0.3 | −0.630 |
| Illinois (131) | 4.4 | 3.2 | 1.3 | 2.870*** |
| Tennessee (133) | 3.7 | 4.2 | −0.5 | −1.328 |
| Composite test statistic | | | | 1.717 |

*$\alpha < 0.05$; ***$\alpha < 0.01$.

was detected between it and the preseason adult female survival estimate of 50.7% (SE = 3.1%). Western Lake Erie(16) data were limited and available only for males. The initial Brownie results for Lake Erie(16) indicated that the data fit Model $H_0$ best, i.e., there was no difference between young and adult male survival rates, therefore the data were pooled. This result is unlikely (see Table 20), and the data set is suspect. The $z$ values in Table 25, exclusive of the two data sets above, do not suggest a difference in survival rates between preseason-banded and winter-banded black duck populations in the same or related geographic areas.

## *Relative Importance of Hunting and Nonhunting Mortality*

Hunting mortality frequently accounts for half or more of total annual black duck mortality (Geis et al.

Table 25. *Results of testing the hypothesis that adult black duck preseason survival estimates are the same as adult black duck winter survival estimates (bandings are from similar geographic areas).*

| Reference areas | | | Males | Females |
|---|---|---|---|---|
| Preseason | vs. | Winter | $z$ Value | $z$ Values |
| **State** | | | | |
| Maine | | Maine | −1.700* | 0.604 |
| Massachusetts | | Massachusetts | −0.678 | −0.561 |
| Michigan | | Michigan | 0.244 | — |
| New York | | New York | −0.992 | −1.104 |
| **Major** | | | | |
| W Lk Erie (16) | | Lk Erie (09) | −1.778* | — |
| W Lk Ont (13) | | Lk Ont (08) | −0.004 | −0.957 |
| E Lk Ont (12) | | Lk Ont (08) | −0.500 | −1.000 |
| S Que (04) | | W LI & Hudson R (04) | −0.266 | — |

*$\alpha < 0.1$.

Table 26. *Estimates of average recovery rates, mortality rates, and kill rates, and the average percent of total hunting deaths of adult black ducks in North America (preseason bandings).*

| State | Canadian recovery rate | U.S. recovery rate | Average mortality rate | Canadian[1] kill rate | U.S.[2] kill rate | Percent due to hunting |
|---|---|---|---|---|---|---|
| **Male** | | | | | | |
| ME | 0.5 | 6.0 | 35.1 | 1.8 | 18.1 | 56.7 |
| MA | 0.2 | 6.0 | 25.5 | 0.8 | 18.1 | 74.1 |
| MI | 0.6 | 6.5 | 36.6 | 2.3 | 19.6 | 59.8 |
| NY | 1.4 | 6.1 | 40.4 | 5.3 | 18.4 | 58.7 |
| ON | 0.1 | 3.8 | 38.5 | 0.4 | 11.4 | 30.6 |
| QU | 3.4 | 3.3 | 35.2 | 12.8 | 9.9 | 64.5 |
| **Mean** | 1.0 | 5.3 | 35.2 | 3.9 | 15.9 | 57.4 |
| **Female** | | | | | | |
| ME | 1.0 | 7.6 | 49.3 | 3.8 | 22.9 | 54.2 |
| MA | 0.6 | 5.5 | 63.9 | 2.3 | 16.6 | 29.6 |
| MI | 0.6 | 6.2 | — | — | — | — |
| NY | 1.8 | 6.2 | 46.6 | 6.8 | 18.7 | 54.7 |
| ON | 3.9 | 3.0 | 48.9 | 14.7 | 9.0 | 48.5 |
| QU | 3.2 | 2.6 | 39.7 | 12.0 | 7.8 | 49.9 |
| **Mean** | 1.9 | 5.2 | 49.7 | 7.9 | 15.0 | 47.4 |

[1] Canadian band reporting rate = 0.32.
[2] U.S. band reporting rate = 0.40.
Rates based on preliminary results from the black duck reward band study (data files: Office of Migratory Bird Management and Migratory Bird Habitat and Research Laboratory, U.S. Fish and Wildlife Service).

1971:49), and in some years about one-fourth of the mallard fall population is killed by hunters (Anderson and Burnham 1976:1). Moisan et al. (1967) estimated that between 15 and 20% of the fall population of green-winged teal was killed by hunters.

The proportion of black duck mortality related to hunting mortality (based on preseason bandings) is shown in Table 26 for adults, and in Table 27 for young. These results are considerably different than those reported by Anderson (1975:24) for the mallard. A comparison of our findings shows:

| | *Hunting mortality as a proportion of total mortality* | | | |
|---|---|---|---|---|
| | Adult males | Adult females | Young males | Young females |
| Black duck | 57 | 47 | 66 | 64 |
| Mallard | 55 | 42 | 51 | 46 |

The results for adult males are similar, but adult female black ducks probably sustain proportionally greater losses to hunting than do adult female mallards. Young black ducks of both sexes sustain substantially greater hunting mortality losses than young mallards; the difference averages 16.5% (both sexes). Clearly, hunting mortality accounts for a greater proportion of total mortality in black duck populations than in mallard populations. The relatively low values for adult females compared to the other age–sex classes indicate a higher adult female mortality rate on the breeding grounds.

I used a crippling loss value of 0.17 compared to Anderson's value of 0.20, and a constant band reporting rate value (0.40—U.S., 0.32—Canada), whereas Anderson used annual reporting rate corrections to account for distance of the recovery from the banding site, and for an annually declining reporting rate (Henny and Burnham 1976). However, the mallard mean values for "Percent Due to Hunting" show a change of less than 2% when the crippling rate of 0.17 is applied to Anderson's results.

The results of a similar analysis of winter bandings are given by flyways in Table 28 for adult males and in Table 29 for adult females. Remarkably close agreement between the Atlantic and Mississippi Flyways indicates that hunting mortality accounts for the same proportion

Table 27. *Estimates of average recovery rates, mortality rates, and kill rates, and the average percent of total hunting deaths of young black ducks in North America (preseason bandings).*

| State | Canadian recovery rate | U.S. recovery rate | Average mortality rate | Canadian[1] kill rate | U.S.[2] kill rate | Percent due to hunting |
|---|---|---|---|---|---|---|
| **Male** | | | | | | |
| ME | 0.9 | 9.9 | 54.7 | 3.4 | 29.8 | 60.7 |
| MA | 0.2 | 9.8 | 41.8 | 0.8 | 29.5 | 72.5 |
| MI | 0.7 | 9.5 | 57.0 | 2.6 | 28.6 | 54.7 |
| NY | 2.5 | 10.0 | 55.2 | 9.4 | 30.1 | 71.6 |
| ON | 7.5 | 3.6 | 52.7 | 28.2 | 10.8 | 74.0 |
| QU | 6.9 | 3.6 | 61.2 | 26.0 | 10.8 | 60.1 |
| **Mean** | 3.1 | 7.7 | 53.8 | 11.7 | 23.3 | 65.6 |
| **Female** | | | | | | |
| ME | 0.5 | 10.6 | 54.8 | 1.9 | 31.9 | 61.7 |
| MA | 0.9 | 9.9 | — | — | — | — |
| MI | 1.1 | 9.1 | — | — | — | — |
| NY | 2.3 | 9.9 | 55.6 | 8.7 | 29.8 | 69.2 |
| ON | 7.2 | 3.8 | 57.0 | 27.1 | 11.4 | 67.5 |
| QU | 5.6 | 3.8 | 58.5 | 21.1 | 11.4 | 55.6 |
| **Mean** | 2.9 | 7.9 | 56.5 | 14.7 | 21.1 | 63.5 |

[1] Canadian band reporting rate = 0.32.
[2] U.S. band reporting rate = 0.40.
Rates based on preliminary results from the black duck reward band study (data files: Office of Migratory Bird Management and Migratory Bird Habitat and Research Laboratory, U.S. Fish and Wildlife Service).

Table 28. *Estimates of average recovery rates, mortality rates, and kill rates, and the average percent of total hunting deaths of adult male black ducks in North America (winter bandings).*

| Flyway/ state | Canadian recovery rate | U.S. recovery rate | Average mortality rate | Canadian[1] kill rate | U.S.[2] kill rate | Percent due to hunting |
|---|---|---|---|---|---|---|
| **Atlantic** | | | | | | |
| DE | 0.7 | 3.3 | 27.2 | 2.6 | 9.9 | 46.0 |
| ME | 0.5 | 3.9 | 16.5 | 1.9 | 11.7 | 82.4 |
| MD | 0.5 | 3.6 | 29.9 | 1.9 | 10.8 | 42.5 |
| MA | 0.6 | 2.8 | 24.7 | 2.3 | 8.4 | 43.3 |
| NJ | 0.6 | 3.7 | 31.2 | 2.3 | 11.1 | 42.9 |
| NY | 1.0 | 4.0 | 33.1 | 3.8 | 12.0 | 47.7 |
| NC | 0.5 | 2.6 | 31.5 | 1.9 | 7.8 | 30.8 |
| VA | 0.4 | 2.9 | 31.2 | 1.5 | 8.7 | 32.7 |
| **Mean** | 0.6 | 3.0 | 28.2 | 2.3 | 10.1 | 46.0 |
| **Mississippi** | | | | | | |
| IL | 0.5 | 3.6 | 32.8 | 1.9 | 10.8 | 38.7 |
| MI | 1.6 | 2.7 | 31.1 | 6.0 | 8.1 | 45.3 |
| OH | 1.6 | 3.2 | 32.3 | 6.0 | 9.6 | 48.3 |
| TN | 1.0 | 3.2 | 28.2 | 3.8 | 9.6 | 47.5 |
| **Mean** | 1.2 | 3.2 | 31.1 | 4.4 | 9.5 | 45.0 |

[1] Canadian band reporting rate = 0.32.
[2] U.S. band reporting rate = 0.40.
Rates based on preliminary results from the black duck reward band study (data files: Office of Migratory Bird Management and Migratory Bird Habitat and Research Laboratory, U.S. Fish and Wildlife Service).

of total mortality within wintering black duck populations in both flyways; about 46% for males, 29% for females. Greater mortality between the winter banding period and the fall hunting season accounts for the lower proportion of hunting mortality attributable to total mortality in winter populations as compared to preseason populations. The substantially lower proportion of mortality in adult females attributable to hunting reflects a higher mortality rate during the breeding season (Gilmer et al. 1977; Johnson and Sargeant 1977).

While these results indicate a higher proportion of total mortality attributable to hunting mortality for black ducks than was noted by Anderson for mallards (59% this study vs. 49%—average of all age–sex classes), the proportion is considerably lower than Crissey's (1963b) estimate of 82% for mallards. Crissey gave no comparable estimate for black ducks, but the data he presented relative to black duck recovery and mortality rates suggest that about 45% of total black duck mortality was attributable to hunting during the period 1945–1960. Geis et al. (1971:49) reported that 50% of total black duck mortality was attributable to hunting. Fewer black ducks (compared to the early 1950's), increased hunter numbers, and an increase in the number of trips afield per hunter (Martin and Carney 1977:14–16) presumably have caused a significant increase in the proportion of black ducks that die from hunting. Whether this has affected black duck annual survival rates or not is a question of immediate importance.

## *The Effect of Exploitation on Survival*

Several investigators (Geis 1963; Geis et al. 1971; Anderson 1975; Anderson and Burnham 1976; Moisan et al. 1967) have noted the effect of hunting regulations on the size of the waterfowl harvest and the harvest rate. Hunting regulations also have been reported to be directly related to survival rates (Geis 1963, 1972a, 1972b; Geis and Crissey 1969; Crissey, 1969, 1970; Moisan et al. 1967; Geis and Tabor 1963; Geis et al. 1971; Martinson et al. 1968).

However, Anderson and Burnham (1976:10) and Hopper et al. (1978) have shown that the assumptions

Table 29. *Estimates of average recovery rates, mortality rates, and kill rates, and the average percent of total hunting deaths of adult female black ducks in North America (winter bandings).*

| Flyway/ state | Canadian recovery rate | U.S. recovery rate | Average mortality rate | Canadian[1] kill rate | U.S.[2] kill rate | Percent due to hunting |
|---|---|---|---|---|---|---|
| **Atlantic** | | | | | | |
| DE | 0.5 | 3.3 | 36.6 | 1.9 | 9.9 | 32.2 |
| ME | 0.5 | 3.3 | 25.8 | 1.9 | 9.9 | 45.7 |
| MD | 0.9 | 2.7 | 45.6 | 3.4 | 8.1 | 25.2 |
| MA | 0.8 | 2.3 | 40.2 | 3.0 | 6.9 | 24.6 |
| NJ | 0.9 | 2.5 | 39.0 | 3.4 | 7.5 | 27.9 |
| NY | 1.1 | 3.3 | 44.8 | 4.1 | 9.9 | 31.3 |
| NC | 1.2 | 2.2 | 49.4 | 4.5 | 6.6 | 22.5 |
| VA | 0.7 | 1.9 | 32.3 | 2.6 | 5.7 | 25.7 |
| **Mean** | 0.8 | 2.7 | 39.2 | 3.1 | 8.1 | 29.4 |
| **Mississippi** | | | | | | |
| IL | 0.4 | 2.5 | 40.5 | 2.3 | 7.5 | 24.2 |
| MI | 1.2 | 3.3 | — | — | — | — |
| OH | 1.4 | 2.8 | 51.9 | 5.3 | 8.4 | 26.4 |
| TN | 1.1 | 3.1 | 40.5 | 4.1 | 9.3 | 33.1 |
| **Mean** | 1.0 | 2.9 | 44.3 | 3.9 | 8.4 | 27.9 |

[1] Canadian band reporting rate = 0.32.
[2] U.S. band reporting rate = 0.40.
Rates based on preliminary results from the black duck reward band study (data files: Office of Migratory Bird Management and Migratory Bird Habitat and Research Laboratory, U.S. Fish and Wildlife Service).

and statistical procedures used previously to evaluate the relationship of average annual recovery rates to average annual survival rates are invalid and have led to spurious results. Recently, Burnham and Anderson (1979) showed that waterfowl data do not generally meet the restrictive assumptions of the composite–dynamic life table method of estimating recovery and survival rates (the composite–dynamic method was used by most of the authors cited above), and Brownie et al. (1978:170) presented a review of the major statistical and biological considerations met by the so-called ''modern methods'' that make them superior to other procedures. Therefore the conclusion that a direct relationship exists between recovery rates and survival rates, which was based on information derived from an inappropriate model, is erroneous.

Anderson and Burnham (1976:5–11) developed two hypotheses to relate hunting mortality to annual survival rates. The first hypothesis assumes complete compensation for hunting losses by a proportional reduction in nonhunting mortality factors (an inverse relationship). The second hypothesis assumes complete additivity of hunting mortality to nonhunting mortality. Thus, removal of a part of the population by hunting creates a proportional reduction in the size of the next year's breeding population. Anderson and Burnham tested these hypotheses by comparing the average annual survival rate of mallards in years of restrictive regulations versus years of liberal regulations and were unable to demonstrate that survival rates increased in years of restrictive hunting regulations. However, they noted that beyond a certain threshold level C, additive mortality might occur. Moreover, the threshold level would more likely be reached on local areas in portions of the breeding grounds than over the population's entire range. The possible vulnerability of black ducks to local overharvest has been cited by several waterfowl biologists (Spencer 1980; Reed and Boyd 1974; Mendall 1949).

## *Effects of Restrictive Versus Liberal Regulations*

Using methods described in Brownie et al. (1978) and in Anderson and Burnham (1976), I examined the effect of hunting under restrictive versus liberal regula-

tions on black duck survival rates. The major difficulty was to find years in which hunting regulation changes were substantial enough to permit a change in survival rates to be measured. The results of preseason banding tests for individual states or minor reference areas are presented in Table 30 for recovery rates, Table 31 for survival rates, and are summarized in Table 32. Corresponding results for winter bandings are given in Tables 33–35. The regulatory changes that correspond to the restrictive and liberal years used are given in Table 36. Only preseason bandings for New York (and New York (122)) were adequate for testing. Significant differences in recovery rates ($P < 0.05$) were noted for young birds and for adult males; recovery rates were higher in years of liberal hunting regulations. It is somewhat surprising that greater differences were not detected, since recovery rates are a measure of hunting pressure. Young males showed a significant difference in survival rates, but survival rates were higher in the liberal season years ($P < 0.05$). The test compared 36- to 45-day seasons and a two black duck daily bag limit to seasons of 50 to 60 days and a one black duck daily bag limit. The unexpected results were caused by an abnormally high and quite unlikely annual survival estimate (0.71, SE = 0.26) in 1 of the 3 years (1971) in the liberal hunting regulations test group. Although record high levels of hunter participation occurred during the three liberal season years (1969–1971) in New York (Martin and Carney 1977:96), the minor reference area survival rate estimates for the liberal season years 1969 and 1970 were similar (30.8 and 43.2, respectively) to the survival rate estimates for the 1961 and 1962 restrictive hunting regulations test groups (39.3 and 32.0, respectively).

No significant changes in survival rates of winter banded birds were found in relation to hunting regulations (Table 34), but several instances of significant changes in recovery rates were noted (Table 33—Massachusetts, New Jersey, North Carolina). The degree of variability in the recovery rate estimates reduced the power of the $z$ test to detect small changes.

The most substantial change in season length and bag limits in recent years is represented by the Massachu-

Table 30. *Test results of the null hypothesis that recovery rates in years of restrictive regulations were the same as recovery rates in years of liberal regulations (preseason bandings-single area comparisons).*

| Reference area | Year comparisons: Restrictive | vs. | Liberal | Mean recovery rate: Restrictive | vs. | Liberal | Difference | Test statistic $z$ value |
|---|---|---|---|---|---|---|---|---|
| **State** | | | | | | | | |
| Adult male: | | | | | | | | |
| New York | 1961–62 | | 1950–52 | 6.6 | | 7.9 | 1.2 | 0.842 |
| New York | 1961–62 | | 1969–71 | 6.6 | | 7.6 | −1.0 | −0.733 |
| Young male: | | | | | | | | |
| New York | 1961–62 | | 1950–52 | 11.2 | | 8.7 | 2.4 | 1.957 |
| New York | 1961–62 | | 1969–71 | 11.1 | | 14.0 | −2.9 | −2.034** |
| **Minor** | | | | | | | | |
| Adult male: | | | | | | | | |
| NY (122) | 1961–62,1966–67 | | 1957–59 | 4.3 | | 3.8 | 0.5 | 0.116 |
| NY (122) | 1961–62 | | 1960,1964–65 | 6.5 | | 6.5 | 0.0 | 0.026 |
| NY (122) | 1961–62 | | 1969 | 6.5 | | 9.1 | −2.6 | −1.530* |
| Adult female: | | | | | | | | |
| NY (122) | 1961–62 | | 1960,1964–65 | 4.3 | | 3.6 | 0.7 | 0.441 |
| Young male: | | | | | | | | |
| NY (122) | 1961–62 | | 1960,1964–65 | 11.3 | | 13.8 | −2.4 | −1.845*** |
| NY (122) | 1961–62 | | 1969 | 11.3 | | 12.4 | −1.1 | −0.547 |
| Young female: | | | | | | | | |
| NY (122) | 1961–62 | | 1960,1964–65 | 9.7 | | 11.6 | −1.9 | −1.518* |

*α<0.1; **α<0.05; ***α<0.01.

Table 31. *Test results of the null hypothesis that survival rates in years of restrictive regulations were the same as survival rates in years of liberal regulations (preseason bandings-single area comparisons).*

| Reference area | Year comparisons: Restrictive | vs. | Liberal | Mean survival rate: Restrictive | vs. | Liberal | Difference | Test statistic z value |
|---|---|---|---|---|---|---|---|---|
| **State** | | | | | | | | |
| Adult male: | | | | | | | | |
| New York | 1961–62 | | 1950–52 | 58.5 | | 55.3 | 3.2 | 0.345 |
| New York | 1961–62 | | 1969–71 | 58.5 | | 72.7 | 14.2 | –1.221 |
| Young male: | | | | | | | | |
| New York | 1961–62 | | 1950–52 | 35.7 | | 37.8 | –2.1 | –0.707 |
| New York | 1961–62 | | 1969–71 | 35.7 | | 48.7 | –13.0 | –2.152** |
| **Minor** | | | | | | | | |
| Adult male: | | | | | | | | |
| NY (122) | 1961–62,1966–67 | | 1957–59 | 57.2 | | 63.0 | –5.8 | –1.001 |
| NY (122) | 1961–62 | | 1960,1964–65 | 56.0 | | 50.9 | 5.1 | 0.443 |
| NY (122) | 1961–62 | | 1969 | 56.0 | | 66.7 | –10.7 | –0.403 |
| Adult female: | | | | | | | | |
| NY (122) | 1961–62 | | 1960,1964–65 | 49.9 | | 39.5 | 10.3 | 1.061 |
| Young male: | | | | | | | | |
| NY (122) | 1961–62 | | 1960,1964–65 | 32.1 | | 39.0 | –6.9 | –1.017 |
| NY (122) | 1961–62 | | 1969 | 32.1 | | 31.9 | 0.8 | 0.067 |
| Young female: | | | | | | | | |
| NY (122) | 1961–62 | | 1960,1964–65 | 42.4 | | 37.8 | 4.6 | 0.396 |

**$\alpha<0.05$.

setts (and Massachusetts(032)) data set for 1966–1969. The change relates to The Special Late Black Duck Season (Martin et al. 1967) conducted in 1966 and 1967 in Maine, New Hampshire, and Massachusetts (Table 36). Despite season length changes of + 14 and + 25 days and a doubling of the black duck daily bag limit for the 1966 25-day season extension, no change in average annual survival rate was noted for the liberal seasons although substantial increases in total harvest were noted (Table 36). The evidence presented does not support the argument that liberal hunting regulations reduce black duck survival rates of local wintering populations.

One major objection to the Massachusetts test is that harvest in one state or minor reference area scarcely can be expected to influence the overall survival rate of black ducks. The argument is valid. The tests shown could only suggest a local effect of hunting on birds banded in a given area. But consider the Massachusetts winter bandings again. My analysis of recovery distributions (to be reported in a separate publication) showed that 19% of all first year recoveries of birds winter banded in Massachusetts occurred in Canada, 66% occurred in Massachusetts, and 14% occurred elsewhere in the Atlantic Flyway, primarily in Maine and New Hampshire. Regulations in Canada did not change during the 4 years tested, therefore a significant change in recovery distribution there is unlikely. Maine and New Hampshire both participated in the Special Late Black Duck Season; therefore, increased black duck kill in those states, if it adversely affected the survival of migrating Massachusetts winter banded black ducks to a significant degree, would have been detected by the test (Maine and New Hampshire were excluded from the test because of insufficient winter bandings in 1968 and 1969). A similar relationship between Canadian and U.S. band recovery distribution (because of unchanged regulations) applies to the other northern state winter banding data sets tested, but states in the mid-Atlantic and southern portions of the flyway take smaller proportions (and therefore smaller samples) of first year band recoveries of winter banded birds, which reduces the power of the $z$ tests to detect a difference if it occurs. Therefore, if results in mid-latitude

Table 32. *Summary of the test results of the null hypothesis that recovery rates and survival rates in years of restrictive regulations were the same as recovery rates and survival rates in years of liberal regulations (preseason bandings-single area comparisons).*

| | Year comparisons | | | Recovery rates–test statistic $z$ value | | | |
|---|---|---|---|---|---|---|---|
| | | | | Adult | | Young | |
| Reference areas | Restrictive | vs. | Liberal | Male | Female | Male | Female |
| **State** | | | | | | | |
| New York | 1961–62 | | 1950–52 | –0.733 | — | 1.957 | — |
| New York | 1961–62 | | 1969–71 | 0.441 | — | –2.034** | — |
| **Minor** | | | | | | | |
| NY (122) | 1961–62,1966–67 | | 1957–59 | 0.116 | — | — | — |
| NY (122) | 1961–62 | | 1960,1964–65 | –0.026 | 0.441 | –1.845** | –1.518* |
| NY (122) | 1961–62 | | 1969 | –1.530* | — | –0.547 | — |

| | Year comparisons | | | Survival rates–test statistic $z$ value | | | |
|---|---|---|---|---|---|---|---|
| | | | | Adult | | Young | |
| Reference areas | Restrictive | vs. | Liberal | Male | Female | Male | Female |
| **State** | | | | | | | |
| New York | 1961–62 | | 1950–52 | 0.345 | — | –0.707 | — |
| New York | 1961–62 | | 1969–71 | –1.221 | — | –2.152** | — |
| **Minor** | | | | | | | |
| NY (122) | 1961–62,1966–67 | | 1957–59 | –1.001 | — | — | — |
| NY (122) | 1961–62 | | 1960,1964–65 | 0.443 | 0.396 | –1.017 | 0.396 |
| NY (122) | 1961–62 | | 1969 | –0.403 | — | 0.067 | — |

*$\alpha$<0.1; **$\alpha$<0.05.

states show no effect of liberal regulations on survival rates, no valid conclusion can be drawn. But if liberal regulations are shown to cause a significant reduction in average annual survival rate in a particular state, then one might conclude, tentatively, that the local wintering black duck population was adversely affected by liberal hunting regulations. No evidence of this condition was observed.

Two additional tests representing a larger geographic area were made by grouping the recovery and survival data from several states or reference areas into restrictive or liberal seasons. In one test, 1 restrictive year was compared to 1 liberal year. The other test compared several restrictive years to several liberal years. The results appear in Table 37 for recovery rate comparisons, and in Table 38 for survival rate comparisons. There is no evidence in either test that liberal hunting regulations affected the survival of black duck wintering populations, although in both cases recovery rates increased significantly. This finding is in agreement with results obtained by Hyland and Gabig (1980:12) for wintering mallard populations in the Central Flyway. Anderson and Burnham (1976:23) analyzed mallard preseason banding data and were unable to reject the null hypothesis that annual survival rates in years with restrictive hunting regulations were the same as the annual survival rates in years of liberal regulations.

The findings of significance for adult female and young recovery rates ($P < 0.01$ and $P < 0.05$, respectively) are not surprising based on the results of earlier recovery rate tests; however, the nonsignificant finding for adult males (Table 37) is unexpected, based on the results of recovery rate tests presented earlier.

The failure to detect a significant difference in survival rates under the null hypothesis may relate more directly on data quantity and quality than to the relationship being evaluated, or to restrictive versus liberal comparisons that were not "different" enough to effect a change in survival. I can only infer that the similar findings for mallards (preseason) which used larger sample sizes and greater differences between restrictive and lib-

Table 33. *Test results of the null hypothesis that recovery rates in years of restrictive regulations were the same as recovery rates in years of liberal regulations (winter bandings-single area comparisons).*

| Reference areas | Year comparisons: Restrictive | vs. | Liberal | Mean recovery rate: Restrictive | vs. | Liberal | Difference | Test statistic z value |
|---|---|---|---|---|---|---|---|---|
| **State** | | | | | | | | |
| Adult male: | | | | | | | | |
| Massachusetts | 1968–69 | | 1966–67 | 2.9 | | 4.3 | −1.4 | −3.359*** |
| New Jersey | 1963–65,1968–69 | | 1952–54 | 4.3 | | 6.0 | −1.7 | −1.604** |
| Tennessee | 1963,1968–69 | | 1966,1970 | 4.5 | | 4.2 | 0.3 | 0.393 |
| Adult female: | | | | | | | | |
| Massachusetts | 1968–69 | | 1966–67 | 2.8 | | 3.4 | −0.6 | −0.996 |
| **Minor** | | | | | | | | |
| Adult male: | | | | | | | | |
| MA (032) | 1971–73 | | 1940–41 | 1.7 | | 4.0 | −2.3 | −1.828** |
| NJ (063) | 1965,1968–69 | | 1970–72 | 3.9 | | 3.5 | 0.4 | 0.286 |
| NY (081) | 1966–67 | | 1956–58 | 6.1 | | 8.0 | −1.9 | −1.137 |
| NC (052) | 1967–68 | | 1969–71 | 2.6 | | 3.4 | −0.8 | −1.203 |
| IL (131) | 1969 | | 1970–71 | 3.7 | | 4.9 | −1.2 | −0.144 |
| MI (123) | 1968–69 | | 1970 | 3.4 | | 4.2 | −0.8 | −0.578 |
| TN (113) | 1963,1968–69 | | 1970–71 | 3.8 | | 5.4 | −1.6 | −0.235 |
| TN (133) | 1968–69 | | 1966, 1970–71 | 3.9 | | 3.4 | 0.5 | 0.993 |
| Adult female: | | | | | | | | |
| MD (055) | 1961–62 | | 1957–58 | 4.1 | | 3.8 | 0.3 | 0.228 |
| NJ (063) | 1965,1968–69 | | 1970–72 | 3.3 | | 3.3 | 0.0 | 0.000 |
| NC (052) | 1967–68 | | 1969–71 | 1.7 | | 4.6 | −2.9 | −3.324*** |
| TN (113) | 1963,1968–69 | | 1966, 1970 | 5.0 | | 4.5 | 0.5 | 0.474 |
| TN (133) | 1968–69 | | 1966,1970–71 | 3.6 | | 3.7 | −0.1 | −0.050 |

**$\alpha<0.05$; ***$\alpha<0.01$.

eral regulations with respect to season length and daily bag limit apply also to the closely related black duck.

## *Correlation Analyses of Recovery Rates*

Several correlation analyses were completed to evaluate (1) the relationship of season length to recovery rate, (2) the relationship of recovery rate to survival rate using independent estimates of each parameter, and (3) the relationship between preseason recovery rates (indices to harvest rates) and estimates of overwinter survival rates.

No significant relationship between season length and recovery rate was detected for any age–sex class of preseason banded birds from New York, Maine, or Massachusetts. However, all r values except one (New York adult female) were positive. The r values ranged between $r = 0.158$ and 0.411.

Recovery rates of winter bandings from 10 states and 2 minor reference areas also were tested against season length. There were 103 datum points for males and 80 datum points for females. A significant positive correlation ($r = 0.303$, $P < 0.1$) was noted for adult males. The r value for adult females was negative and nonsignificant ($r = -0.177$) and suggests that long, and presumably late, seasons have relatively little effect on the harvest rate of adult females. Since adult females are harvested in greatest numbers early in the season and on the breeding grounds (Geis et al. 1971:34; Anderson and Henny 1972:81), this result is not surprising. Furthermore, winter banded females experience greater mortality than do males between the winter banding period and the fall–winter harvest and therefore are proportionately less available to be harvested.

The significant finding for winter banded adult males is not strong, but relates to their relatively greater vulnerability to harvest on the wintering grounds and late in the hunting season (Geis et al. 1971:34; Anderson and Henny 1972:81). An increase in season length during this period

Table 34. *Test results of the null hypothesis that survival rates in years of restrictive regulations were the same as recovery rates in years of liberal regulations (winter bandings-single area comparisons).*

| Reference areas | Year comparisons: Restrictive | vs. | Liberal | Mean survival rate: Restrictive | vs. | Liberal | Difference | Test statistic z value |
|---|---|---|---|---|---|---|---|---|
| **State** | | | | | | | | |
| Adult male: | | | | | | | | |
| Massachusetts | 1968–69 | | 1966–67 | 78.6 | | 76.3 | 2.3 | 0.212 |
| New Jersey | 1963–65,1968–69 | | 1952–54 | 66.1 | | 66.8 | –0.7 | –0.088 |
| Tennessee | 1963,1968–69 | | 1966,1970 | 64.0 | | 50.7 | 13.3 | 1.372 |
| Adult female: | | | | | | | | |
| Massachusetts | 1968–69 | | 1966–67 | 71.0 | | 62.3 | 8.6 | 0.681 |
| **Minor** | | | | | | | | |
| Adult male: | | | | | | | | |
| MA (032) | 1971–73 | | 1940–41 | 73.8 | | 81.0 | –7.2 | –0.566 |
| NJ (063) | 1965,1968–69 | | 1970–72 | 73.1 | | 69.3 | 3.8 | 0.509 |
| NY (081) | 1966–67 | | 1956–58 | 69.9 | | 64.9 | 5.0 | 0.370 |
| NC (052) | 1967–68 | | 1969–71 | 44.2 | | 62.9 | –18.7 | –0.983 |
| IL (131) | 1969 | | 1970–71 | 67.4 | | 64.8 | 2.6 | 0.191 |
| MI (123) | 1968–69 | | 1970 | 78.9 | | 75.1 | 3.7 | 0.120 |
| TN (113) | 1963,1968–69 | | 1966,1970 | 59.7 | | 80.0 | –20.3 | –1.260 |
| TN (133) | 1968–69 | | 1966,1970–71 | 75.9 | | 71.8 | 4.1 | 0.472 |
| Adult female: | | | | | | | | |
| MD (055) | 1961–62 | | 1957–58 | 61.3 | | 74.9 | –13.6 | –0.600 |
| NJ (063) | 1965,1968–69 | | 1970–72 | 77.9 | | 60.5 | 17.4 | 1.451 |
| NC (052) | 1967–68 | | 1969–71 | 44.2 | | 62.9 | –18.7 | –0.983 |
| TN (113) | 1968–69 | | 1966,1970–71 | 59.2 | | 54.3 | 5.0 | 0.496 |

Table 35. *Summary of the test results of the null hypothesis that recovery rates and survival rates in years of restrictive regulations were the same as recovery rates in years of liberal regulations (winter bandings—single area comparisons).*

| Reference areas | Year comparisons: Restrictive | vs. | Liberal | Recovery rates, Test statistic z value: Male | Female | Survival rates, Test statistic z value: Male | Female |
|---|---|---|---|---|---|---|---|
| **State** | | | | | | | |
| Massachusetts | 1968–69 | | 1966–67 | –3.359*** | –0.996 | 0.212 | 0.681 |
| New Jersey | 1963–65,1968–69 | | 1952–54 | –1.640** | — | –0.088 | — |
| Tennessee | 1963,1968–69 | | 1966,1970 | 0.393 | — | –1.260 | — |
| **Minor** | | | | | | | |
| Mass (032) | 1971–73 | | 1940–41 | –1.828** | — | 0.566 | — |
| NC (052) | 1967–68 | | 1969–71 | –1.203 | –3.324*** | –0.526 | –0.983 |
| Md (055) | 1961–62 | | 1957–58 | — | 0.228 | — | –0.600 |
| NJ (063) | 1965,1968–69 | | 1970–72 | 0.286 | 0.000 | 0.509 | 1.451 |
| NY (081) | 1966–67 | | 1956–58 | –1.137 | — | 0.370 | — |
| Tenn (113) | 1963,1968–69 | | 1966,1970 | –0.235 | — | –1.260 | — |
| Mich (123) | 1968–69 | | 1970 | –0.578 | — | 0.120 | — |
| Ill (131) | 1969 | | 1970–71 | –0.144 | — | 0.191 | — |
| Tenn (133) | 1968–69 | | 1966,1970–71 | 0.993 | –0.050 | 0.472 | 0.496 |

**$\alpha$<0.05; ***$\alpha$<0.01.

Table 36. *Summary of waterfowl hunting regulations and harvest estimates for selected states used to test the hypothesis that survival rates in years of restrictive regulations are the same as survival rates in years of liberal regulations.*

| | Restrictive years | | | | | Liberal years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Flyway/State | Year | Opening day | Season length | Daily bag limit | Harvest | Year | Opening day | Season length | Daily bag limit | Harvest |
| **Atlantic** | | | | | | | | | | |
| Massachusetts | 1968 | 0–12 | 45 | 2 | 36,268 | 1940 | 0–16 | 60 | 10 | — |
| | 1969 | 0–20 | 50 | 2 | 28,081 | 1941 | 0–18 | 60 | 10 | — |
| | 1971 | 0–20[a] | 40 | 2 | 25,149 | 1966 | 0–15 | 55/25[b] | 3/4[b] | 26,490[b] |
| | | 0–23 | | | | | | | | 22,000 |
| | 1972 | 0–20[a] | 45 | 2 | 27,674 | 1967 | 0–20 | 45/14[b] | 2/2[b] | 23,382[b] |
| | | N–18 | | | | | | | | 14,000 |
| | 1973 | 0–20[a] | 40 | 2 | 27,705 | | | | | |
| | | N–16 | | | | | | | | |
| New Jersey | 1963 | 0–26 | 45 | 2 | 45,869 | 1952 | N–7 | 55 | 4 | 61,500 |
| | 1964 | 0–24 | 45 | 2 | 37,575 | 1953 | N–6 | 60 | 4 | 44,600 |
| | 1965 | 0–23 | 45 | 2 | 39,284 | 1954 | N–3 | 60 | 4 | 36,400 |
| | 1968 | 0–19 | 45 | 2 | 41,868 | 1970 | 0–17 | 60 | | 42,196 |
| | 1969 | 0–18 | 45 | 2 | 49,259 | 1971 | 0–16 | 60 | | 59,183 |
| | | | | | | 1972 | 0–14 | 60 | | 31,852 |
| New York | 1961 | 0–13[d] | 36/40 | 2 | 39,183 | 1956 | 0–15[d] | 70 | 4 | 73,500 |
| | | N–21 | | | | | N–3 | | | |
| | 1962 | 0–12[d] | 45 | 2 | 36,295 | 1957 | 0–12[d] | 70 | 4 | 59,100 |
| | | 0–20 | | | | | N–2 | | | |
| | 1966 | 0–15 | 45/50 | 2 | 33,887 | 1958 | 0–16[d] | 54/60[d] | 4 | 59,800 |
| | | | | | | | N–10 | | | |
| | 1967 | 0–14[d] | 45/50 | 2 | 39,503 | 1959 | 0–16[d] | 50 | 4 | 43,000 |
| | | N–4 | | | | | N–14 | | | |
| | | | | | | 1960 | 0–14[d] | 50 | 3 | 44,800 |
| | | | | | | | N–19 | | | |
| | | | | | | 1964 | 0–17 | 50/45[d] | 3 | 31,470 |
| | | | | | | 1965 | 0–16 | 55/50[d] | 3 | 35,238 |
| | | | | | | 1969 | 0–6[d] | 57/50[d] | 1[e] | 45,337 |
| | | | | | | | N–17 | | | |
| | | | | | | 1970 | 0–6[d] | 60 | 1[e] | 45,596 |
| | | | | | | | N–16 | | | |
| | | | | | | 1971 | 0–11[d] | 60 | 1[e] | 48,624 |
| | | | | | | | N–15 | | | |
| North Carolina | 1967 | N–18 | 50 | 2 | 12,901 | 1969 | N–20 | 57 | 1[e] | 14,235 |
| | 1968 | N–27[f] | 50 | 2 | 17,769 | 1970 | N–18 | 60 | 1[e] | 14,445 |
| | | | | | | 1971 | N–20 | 60 | 1[e] | 10,512 |
| **Mississippi** | | | | | | | | | | |
| Illinois | 1969 | N–1 | 30 | 2 | 9,123 | 1970 | 0–17 | 55 | | 8,032 |
| | | | | | | 1971 | 0–23 | 50 | | 4,061 |
| Michigan | 1968 | 0–10 | 30 | 2 | 11,682 | 1969 | 0–10 | 40 | 4 | 21,445 |
| | | | | | | 1970 | 0–7 | 55 | 6 | 21,561 |
| Tennessee | 1963 | D–2 | 35 | 2 | 10,786 | 1966 | N–25 | 45 | 4 | 11,007 |
| | 1968 | D–7 | 30 | 2 | 9,066 | 1970 | D–4 | 45 | 4 | 19,230 |
| | 1969 | D–6 | 30 | 2 | 8,438 | 1971 | N–13 | 50 | 4 | 14,658 |

[a]Zoned waterfowl season-opening day differed in 2 portions of the state.
[b]Second entry relates to the experimental late black duck season in 1966 and 1967.
[c]Point system regulations: black duck = 70 points or 2 per day.
[d]Second entry represents an opening day or differed from Upstate New York regulations.
[e]Liberal with respect to season length only.
[f]Statewide October segment of 4 days; the remainder of the season opened on November 27.

Table 37. *Test results of the null hypothesis that recovery rates in years of restrictive regulations were the same as recovery rates in years of liberal regulations (winter bandings—grouped area comparisons).*

| Reference areas | Year comparisons Restrictive | vs. | Liberal | Mean recovery rate Restrictive | vs. | Liberal | Difference | Test statistic $z$ value |
|---|---|---|---|---|---|---|---|---|
| **State** | | | | | | | | |
| Adult male: | | | | | | | | |
| Maryland | 1967–68,1970 | | 1971 | 3.6 | | 3.9 | –0.3 | –0.889 |
| New York | 1966–68 | | 1969–71 | | | | | |
| North Carolina | 1967–68 | | 1969–72 | | | | | |
| Virginia | 1967–70 | | 1971 | | | | | |
| Adult female: | | | | | | | | |
| Maryland | 1961–62,1967–68, 1970 | | 1971 | 2.9 | | 3.8 | –8.4 | –2.556*** |
| New York | 1966–68 | | 1969–71 | | | | | |
| North Carolina | 1967–68 | | 1969–72 | | | | | |
| Virginia | 1967–70 | | 1971 | | | | | |
| **Minor** | | | | | | | | |
| Adult male: | | | | | | | | |
| NJ (063) | 1968 | | 1970 | 4.2 | | 5.3 | –1.1 | –1.982** |
| TN (113) | | | | | | | | |
| TN (133) | | | | | | | | |
| NY (081) | | | | | | | | |
| Adult female: | | | | | | | | |
| NJ (063) | 1968 | | 1970 | 3.1 | | 4.4 | –1.3 | –2.085** |
| NC (052) | | | | | | | | |
| TN (113) | | | | | | | | |
| TN (133) | | | | | | | | |

**$\alpha<0.05$; ***$\alpha<0.01$.

when adult males are most vulnerable to hunting may influence the recovery rate of adult males.

The relationship of recovery rate to survival rate was evaluated by examining all band recovery data (preseason and winter) on a flyway basis. Unlike the estimates of recovery rate and survival rate derived from a single data set, which are highly correlated (Anderson and Burnham 1976:10), the method employed here assures independence of the two parameters because different data sets were used to derive the two parameter estimates ($\hat{f}$, computed from preseason bandings; $\hat{S}$, computed from winter bandings). Pooling the banding data over a large geographic area removes the effect of locally important recovery rate differences which might bias the test with respect to survival of the overall Atlantic or Mississippi Flyway black duck populations.

A significant negative correlation ($r = -0.277$; $0.1 < P < 0.05$) was detected for adult males in the Atlantic Flyway. The r values for Atlantic Flyway adult females ($r = -0.208$) and for Mississippi Flyway adult males and adult females ($r = -0.098$ and $-0.017$, respectively) were negative but nonsignificant.

The test for evidence of compensatory mortality on the wintering grounds was described in "Methods," page 00. Test results are presented in Table 39. The winter recovery rate ratios were computed for state banding data only, but the ratios were tested with recovery rates derived from state and major reference area preseason banding data. Only one of 28 correlation analyses (14 adult males; 14 adult females) showed a significant positive correlation ($P < 0.05$) between the preseason recovery rate of the breeding population supplying birds to the wintering ground, and the ratio of the early winter:late winter recovery rate of the wintering population. I conclude that the tests show no evidence that compensatory mortality on the wintering grounds occurs in response to preseason

Table 38. *Test results of the null hypothesis that survival rates in years of restrictive regulations were the same as survival rates in years of liberal regulations (winter bandings—grouped area comparisons).*

| Reference areas | Year comparisons: Restrictive | vs. | Liberal | Mean survival rate: Restrictive | vs. | Liberal | Difference | Test statistic $z$ value |
|---|---|---|---|---|---|---|---|---|
| **State** | | | | | | | | |
| Adult male: | | | | | | | | |
| Maryland | 1967–68,1970 | | 1971 | 68.5 | | 77.6 | –9.1 | –1.160 |
| New York | 1966–68 | | 1969–71 | | | | | |
| North Carolina | 1967–68 | | 1969–72 | | | | | |
| Virginia | 1967–70 | | 1971 | | | | | |
| Adult female: | | | | | | | | |
| Maryland | 1961–62,1967–68, 1970 | | 1971 | 54.2 | | 60.8 | –6.6 | –0.797 |
| New York | 1966–68 | | 1969–71 | | | | | |
| North Carolina | 1967–68 | | 1969–72 | | | | | |
| Virginia | 1967–70 | | 1971 | | | | | |
| **Minor** | | | | | | | | |
| Adult male: | | | | | | | | |
| NJ (063) | 1968 | | 1970 | 61.3 | | 70.8 | –9.5 | –0.876 |
| TN (113) | | | | | | | | |
| TN (133) | | | | | | | | |
| NY (081) | | | | | | | | |
| Adult female: | | | | | | | | |
| NJ (063) | 1968 | | 1970 | 49.6 | | 55.2 | –5.6 | –0.506 |
| NC (052) | | | | | | | | |
| TN (113) | | | | | | | | |
| TN (133) | | | | | | | | |

recovery rates (or harvest rates) of those breeding grounds populations that provide significant numbers of black ducks to a particular wintering population. The imprecision and great variability inherent in the recovery rate estimates, particularly those of the early and late winter periods, undoubtedly affected the ability of the tests to detect significant differences if they existed. Possibly different results would be derived from a larger, less variable data source.

## Discussion

The effect of concentrated hunting pressure on local marshes was noted by Hochbaum (1947, 1970), who indicated, with reference to eastern prairie Canada, that hunting seasons on the breeding grounds are too early and hunting pressure is too great. The result is a marsh depleted of its breeding stock. Kirby's (1976) study of radio-monitored mallards in north-central Minnesota revealed that young birds restrict their activities to only those areas used previously. This explains why intensive hunting pressure on a production area can destroy local breeding populations, perhaps in a single season (Kirby 1976:96). Kirby and Cowardin (in press) also concluded that it might be rather easy to exceed Anderson and Burnham's (1976) threshold level, C, on the breeding grounds.

Reed and Boyd (1974) stated that local stocks of black ducks along the south shore of the St. Lawrence River, Quebec, can be depleted by harvest beyond the capacity of the population to maintain itself. They reported that about 20% and 40% respectively of the 1972 and 1973 annual production of black ducks in the Isle–Verte Bay area of the St. Lawrence River was removed by hunting on the opening weekend. They calculated that annual harvest rates for the period 1963–1972 ranged between 20.5% and 31.7%, and postulated that if present harvest trends were to continue, regular overharvest of

Table 39. *Results of the test for evidence of compensatory mortality on the wintering grounds following seasons of high hunting mortality.*

| Winter reference area source: Recovery ratio: $\hat{f}$ 15 Dec–31 Jan/$\hat{f}$ 1 Feb–15 Mar | Preseason reference area source: Recovery rate $\hat{f}$ | Correlation coefficient | |
|---|---|---|---|
| | | Males | Females |
| **Atlantic Flyway** | | | |
| Maryland | Maryland | 0.447 | — |
| Massachusetts | Massachusetts | 0.337 | –0.206 |
| | Maritimes (01) | — | 0.444 |
| | St. John & St. Croix R (05) & W Maine (06) | — | 0.174 |
| New Jersey | St. John & St. Croix R (05) & W Maine (06) | –0.189 | 0.797 |
| New York | New York | 0.198 | 0.222 |
| | Massachusetts | 0.011 | 0.733** |
| | Quebec | 0.263 | 0.003 |
| | St. John & St. Croix R (05) & W Maine (05) | 0.061 | 0.199 |
| | E Lake Ont (12) | 0.193 | 0.347 |
| | W Lake Ont (13) | –0.355 | 0.289 |
| Virginia | Ontario | 0.066 | –0.607 |
| | E Lake Ont | –0.502 | –0.275 |
| **Mississippi Flyway** | | | |
| Tennessee | W Lake Ont (13) | –0.210 | –0.265 |
| | Up Gt Lakes (15) | –0.162 | –0.702 |
| | W Lake Erie (16) | –0.109 | — |

$^{**}\alpha<0.05$.

the local breeding population might result. Bartlett (1963) also indicated that the harvest of local birds on Prince Edward Island might be excessive in some years. Is it possible, as Hochbaum (1947) has stated regarding the canvasback, that we are observing conditions on a local level that have a broader geographic effect?

Anderson and Burnham (1976:25) were unable to show that liberal hunting regulations (high harvest rates) resulted in lower survival rates. However, they did recognize that the threshold point for compensatory mortality may have been exceeded in some geographic areas in some years. Rogers et al. (1979) reached a similar conclusion working with more recent mallard banding data.

The survival of adult black ducks (this study—preseason bandings) was found to be similar to mallard adult survival as reported by Anderson (1975). March and Hunt (1978:41) reported similar adult male survival rates, and slightly higher adult female survival rates for mallards banded in Wisconsin. The low survival rate of young male mallards in Wisconsin (38.1%) is similar to that of young male black ducks in Quebec (38.8%), a rate lower than that observed for most young male black ducks. Young female mallards in Wisconsin have higher survival rates (49.9%) than most young female black duck populations examined. Yet, March and Hunt (1978:44) cautioned that shooting losses on local populations may have exceeded Anderson and Burnham's (1976) threshold point in some years. It should be noted that the average production rate in Wisconsin for the period 1961–1972 was only 0.9 young per adult, substantially lower than the more general population production rate reported for black ducks in this study.

Adult mallards in the Mid-Continental Mallard Management Unit survive as well as adult black ducks, but young mallards, females in particular, apparently survive at a slightly higher rate than young black ducks (Anderson 1975: Appendixes A and B). However, mallard production in the area is low and the population is unable to sustain itself without recruitment from outside the management unit. Kirby and Cowardin (in press)

found that the mallard population in north-central Minnesota, an area adjacent to the Mid-Continent Mallard Management Unit, also must be sustained by immigration or else decline. These writers reported an average annual survival rate of 55% for adult females and of 42% for young females, rates very similar to those obtained for black ducks.

The average kill rates computed for adult and young in this study (Tables 26 and 27) exceed the average kill rates computed by Anderson (1975: Table 16) for mallards even after adjustment for the lower crippling loss rate used for black ducks in this study (0.17 vs. 0.20). The difference in average kill rate between young black ducks and young mallards of both sexes is 16.5%, and between adult males and females is 2% and 5%, respectively—in all cases black ducks sustained a higher proportion of mortality by hunting than did mallards.

The data presented in Tables 26 through 29 are subject to great variation, not only in the recovery rate estimates, but in the survival estimates as well. In addition there is a nonnegligible sampling correlation between S and f. Therefore, values for the proportion of total mortality attributed to hunting must be considered indices rather than estimates. Regardless, there can be little question that in general, hunting mortality is a substantially larger component of black duck total mortality than it is of mallard total mortality.

An indication that black ducks are declining is provided by Newell and Boyd (1978) who evaluated black duck harvest in terms of harvest per 1,000 waterfowl hunter days. The major assumption is that black ducks are harvested in proportion to their abundance and to hunting intensity. Therefore, under a given unit of hunting pressure, a decline in harvest per unit of effort would be indicative of a decline in black duck population size. I applied the same method to the United States black duck harvest data (Files, Office of Migratory Bird Management).

Newell and Boyd found that the harvest per unit of effort between 1972–1976 had increased in the Maritime provinces, and had decreased in Quebec and Ontario. In both the Atlantic and Mississippi Flyways, I found that harvest per unit of effort has declined (1961–1979).

Another index of black duck abundance is the average number of black ducks harvested per successful hunter. Newell and Boyd (1974) found general agreement between this statistic for each province (New Brunswick data were anomalous) and the results obtained for each province using the harvest per unit of effort method. I found similar agreement between the two methods relative to United States black duck harvests. Therefore, both of these indicators of black duck population size suggest a general decline except in the Maritime provinces.

The major difference between the mallard populations described above and the heavily harvested black duck populations identified in this study is the higher production rate (P) reported for black ducks. However, biases exist in both the Canadian and United States wing collection surveys (Cooch et al. 1978; Martin and Carney 1977:12). Sorenson (1978) has suggested that U.S. production estimates may be overestimated by 5–10%. Carney (personal communication) stated that a + 10% bias in the production estimate would not be surprising. This bias does not necessarily affect all species equally, because the chronology of the harvest influences the degree of bias in the wing collection survey.

The high recovery rates of black ducks in their primary breeding range in eastern Canada, New England and New York early in the hunting season probably exaggerates the black duck production estimate, and the comparatively low survival rates of young black ducks suggest the possibility that annual production is being exploited excessively, so that recruitment of young into the breeding population is insufficient to maintain population stability. Mallard recovery rates across that species' primary breeding range in prairie Canada are lower than those of the black duck in its primary breeding range, therefore the production estimate bias may be less. Yet in areas where the two species occupy the same general habitats mallard recovery rates are slightly higher (Anderson 1975, Appendixes A and B; this study, Appendixes B–D). In southern Ontario and southwestern Quebec the mallard production rate frequently exceeds the black duck production rate (Files, CWS Harvest Surveys). This may be a response by the mallard to expansion into new habitats, or it may be a result of biased production estimates, or both.

Rogers et al. (1979) examined the relationship between survival rates and harvest rate indices for mallards and concluded that no significant relationship exists. (The harvest rate index was computed independent of the survival rate as the ratio of the total mallard harvest, as estimated from the harvest surveys, divided by the total breeding population size as estimated from the May breeding grounds surveys.) But the correlation analysis of the relationship of black duck preseason recovery rates to winter survival rates across the entire Atlantic Flyway suggests that harvest rates may affect survival rates adversely (adult males:significant negative correlation; all other age–sex classes:nonsignificant, but negative correlations). The significant negative correlation for adult

males in that test is complemented by the positive significant correlation for adult males found in the test of the relationship of season length to recovery rate which indicates that recovery rates (and therefore harvest rates) for that age–sex class increase with an increase in season length. Thus, black duck population growth may be affected (or may have been affected) by conditions favorable to harvest rate increases sufficient to affect the survival rate of one or more age–sex classes. Under such conditions, one would expect hunting mortality to represent a large proportion of total mortality. The indices of hunting mortality as a proportion of total mortality support this contention, but those indices represent rather inaccurate measurements of the hunting mortality to total mortality relationship.

If black duck population growth has been or is being depressed by hunting, one might expect the population to exhibit a high reproductive rate in response to an understocked habitat. Crissey (n.d.) suggests that this is the case with the black duck. This implies a density-dependent relationship between breeding population size and reproductive rate. Evidence of this relationship in mallards was found by Pospahala (Files, Office of Migratory Bird Management). He used Duck Wing Collection Survey Data to compute a measure of production independent of the May Breeding Population Index (BPI) to test the relationship between the size of the breeding population as measured by the May Breeding Ground Survey (Pospahala et al. 1974) and the population production rate P (young per adult female). A significant inverse correlation was found ($r = 0.3544$; $0.1\ P < 0.05$) indicating that in years when the breeding population was low, the production rate was higher than in years when the breeding population was high. The implication for black ducks is that although annual production may be high in response to a declining breeding population, the recruitment of young birds into the breeding population is insufficient to attain the rate of growth inherent in the population and attainable relative to the carrying capacity of its habitat.

The recent gradual but steady dispersion of the mallard into parts of the black duck range (primarily Ontario, the Great Lakes Region, southern Quebec and most of the northeastern United States except Maine, New Hampshire and brackish-to-saline coastal areas to the south) has been described (Johnsgard 1961; Johnsgard and DiSilvestro 1967). The superior competitive ability of the mallard has resulted in the displacement of the black duck from that portion of its range in southern Ontario that supplies birds to the Mississippi Flyway (Collins 1974). In northern Ontario and in boreal habitats elsewhere in eastern Canada the black duck retains its former status, although data presented by Freemark and Cooch (1974) indicate a northward extension by the mallard into boreal habitats in parts of Ontario. Maritime environments still remain the exclusive domain of the black duck. Reed (personal communication) indicated that the eastward movement of the mallard along the St. Lawrence River appears to have halted, at least temporarily, at the brackish–*Spartina* marsh ecotone about 100 miles northeast of Montreal.

The presence of mallards and black ducks as breeding birds in the central and eastern portions of southern Ontario provides a stage from which to view the current concern about the possible overharvest of black ducks. Several factors appear to be acting upon both species in a similar way. The recovery rates of mallards in this region are about 1–2% higher for each age–sex class than those of black ducks (Anderson 1975, Tables A-6, B-5; this study Table 17, Tables C-9 to C-15). The survival of each species is essentially the same, but mallard age ratios in the harvest often are slightly higher (Files, Canadian Wildlife Service). The similar recovery rates suggest that the harvest removes nearly equal proportions of each species from their respective populations. However, the black duck harvest in Ontario has decreased since 1968, whereas the mallard harvest has increased (Freemark and Cooch 1974). Freemark and Cooch attribute the increased size of the combined black duck–mallard harvest to a parallel increase in the number of active hunters. They attribute the proportional increase of mallards in the harvest to relative changes in the size of the breeding populations of the two species.

The conversion of land to an agrarian economy over the past several decades in southern Ontario has favored the mallard, and must be a primary factor related to its eastward spread in the province. More tolerant of human and environmental disturbance, the mallard has found an abundance of suitable nesting sites in southern Ontario where it competes well with the black duck, which adapts less well to highly cultured environments and probably competes unsuccessfully with the mallard for marginal nest sites (Laperle 1974). Thus, assuming all the best nest sites are taken by mallards, the black duck is restricted to less favorable nesting sites in agricultural areas and is restricted to more wooded, boreal nesting habitats. As the mallard continues to adapt to more northern habitats, as Freemark and Cooch imply (see their Tables 9 and 10), the black duck presumably will be forced again into less favorable nesting sites. This should result eventually in a general decline in black duck productivity in areas where the two species compete, with a subsequent reduction in the black duck breeding population. In fact, this may explain, at least partially, what has happened to black duck breeding populations in southern Ontario.

A review may serve to focus on the critical elements of this discussion:

Recovery rates of banded black ducks are high, survival rates of young black ducks are lower than young mallard survival rates, but adult survival rates are essentially the same for both species. The estimated proportion of total mortality caused by hunting is much larger for black ducks, especially the young, than for mallards, but no relationship has been found between liberal and restrictive waterfowl hunting regulations and the survival of either black ducks or mallards. The production rate of black ducks is high, assuming the production estimates are not significantly biased upward, but in southern Ontario and Quebec the mallard production rate is slightly higher. Habitat changes in Ontario, and more recently in southern Quebec, favor the mallard, the more adaptable species. Moreover, the mallard appears to be displacing the black duck through competition for the best nest sites wherever the two species breed in close proximity. Thus a natural shift in population distribution is in progress. Harvest data indicate that black duck numbers have been declining. This trend is supported by Winter Survey data. Only in the Maritime provinces is there an indication that black ducks have not declined. The danger here, as elsewhere across eastern Canada, is that northern black duck populations may be contributing significantly to the harvest, thereby masking possible downward trends in local populations.

Hochbaum (1947) insisted that northern birds could not supply recruits to local breeding populations indefinitely. Cooch (1978), noting the decline of the mallard breeding population in Manitoba (because of intensive hunting pressure?), stated that a reduction of hunting pressure on black ducks and mallards is needed in the United States where the major proportion of the harvest is taken to prevent both species from further decline, and to permit Canadians to participate equitably in the harvest of these resources. Now that the Canadian harvest of black ducks exceeds that of the United States, and if one is willing to assume that harvest is responsible for the decline of the black duck, it seems appropriate to acknowledge that unless both countries reduce hunting pressure on the black duck the species will continue to decline, probably to some lower relatively stable level.

The available evidence does not permit the conclusion that harvest is not affecting survival, primarily because the data used to test that hypothesis are highly variable. Yet there is substantial agreement with the results obtained by Anderson and Burnham (1976:23–24) and Rogers et al. (1979) that there is no relationship between hunting regulations and the survival of mallards (or black ducks?). Conversely, winter banded adult black ducks (1st-year wintering birds included) showed a significant inverse relationship between recovery rate and survival rate in the Atlantic Flyway.

My opinion of the current black duck problem, based on the circumstantial evidence accumulated by this study is that harvest in local areas has been excessive in some years. Those areas with relatively high harvest rates are most suspect. For black ducks this criterion applies to every northern state and every province within the principal breeding range of the species, i.e., from New England and New York to Michigan and across southern Canada from Nova Scotia to Southern Ontario. Recruitment to the breeding population probably has been depressed by the removal of too many young birds. Not only does this ensure a declining population, but in areas where the black duck must compete with the mallard, a numerically depressed breeding population is a decided disadvantage. Production of black ducks in northern areas may be masking local declines, but in the long run those populations may not be capable of sustaining today's level of hunting pressure. Within the geographical area defined, I believe ways must be found to alleviate intense hunting pressure on local black duck populations, especially on young birds.

## Summary

1. Estimates of annual and average annual survival rates for state/province, major, and minor reference areas derived from preseason and winter bandings are presented in six appendixes.
2. Recovery rates from preseason bandings vary significantly for all age–sex classes, by years, and by geographic areas. Changes in hunting regulations which vary by flyways, states, and years are reflected in the recovery rate estimates.
3. Adult males in Eastern Lake Ontario(12) have lower survival rates than adult males in other major reference areas ($z$ tests, corresponding years). Young males in Southern Quebec(04) have lower survival estimates than young males in other major reference areas. Adult and young females showed fewer differences in survival rates.
4. Tests for survival rate differences between geographic areas using preseason banding data for noncorresponding but frequently overlapping years showed that adult females in Southern Quebec(04) have significantly higher survival rates than three other major reference areas tested. Young males in Quebec have lower survival rates than young males in other test areas. Tests of minor reference areas show a

significantly higher survival rate for Quebec(04) adult males compared to New York(122) and Ontario (131). No differences in survival rate were detected in the minor reference area *z* tests for adult females or young.

5. Preseason banded adult males and females survive at a significantly higher rate than young, although the test results between adult and young females were less conclusive than those between adult and young males. Adult males have higher survival rates than adult females although adult male recovery rates are higher. No significant differences were detected between young male and female survival rates.
6. Significant differences exist in the recovery rates of winter banded adult males (corresponding years). The lowest recovery rates are found in Massachusetts, the highest in Maine. No statistically significant differences were found in the adult female tests between areas in corresponding years.
7. Recovery rates (noncorresponding years) of winter banded males and females vary significantly between geographic areas. The results of 43% to 75% of all tests conducted within each geographic area tested (state/province, major and minor reference areas) show statistical significance. Recovery rates of winter banded adult females are lower than the recovery rates of males. This is a reflection of the adult female's greater mortality on the breeding grounds.
8. Survival estimates of winter banded birds show few differences between areas. Differences that were detected resulted from the comparison of a precisely estimated data set with poorly estimated data sets. However, differences in survival estimates probably do exist but are too small to be detected.
9. Winter banded adult males survive at a higher rate than winter banded adult females; they also have significantly higher recovery rates.
10. About 57% of adult males, 47% of adult females, 65% of young males, and 63% of young females (preseason bandings) that die in an average year are killed by hunters. Proportionately more males than females and more young than adults are taken by hunters. These proportions are substantially higher than those reported for mallards.
11. About 46% of winter banded males and 29% of winter banded females that die in an average year are killed by hunters. The lower proportion of hunting mortality compared to preseason banding estimates reflects deaths from nonhunting mortality in the interval between time of banding and the hunting season which, for winter banding, is much longer than for preseason bandings.
12. The annual survival of black ducks averaged over years and across geographic areas is: adult males—63%, adult females—56%, young males and females—43%. No significant difference was shown between the preseason and winter banded survival estimates of adult males and females, respectively.
13. The null hypothesis that survival rates in years of liberal regulations are the same as survival rates in years of restrictive regulations was rejected for young males in New York(122), but the survival rate during the liberal regulation years was significantly higher. The null hypothesis was not rejected for the other age–sex classes in the test, nor did similar tests using winter banding data from several other areas reject the null hypothesis.
14. No significant relationship between season length and recovery rates was found for preseason bandings from New York, Maine, and Massachusetts. However, all age–sex classes tested except New York adult females were positively correlated. A significant positive correlation was shown between season length and the recovery rates of winter banded adult males. The results of a correlation analysis of the relationship of preseason recovery rates to winter survival estimates over the entire Atlantic Flyway were significant and negative for adult males, and nonsignificant but negative for all other age–sex groups. This suggests that sufficiently long seasons may increase adult male recovery rates and affect their survival adversely. This may hold for the other age-sex classes to a lesser degree.
15. No evidence was shown that compensatory mortality occurs on the wintering grounds. However, the great variability of the winter recovery rate estimates used may have obscured the test results if a significant difference existed.

# Part III.

## Simulation Studies

## Methods

### *Time Invariant Matrix Model*

Two simulation models were employed to evaluate the age ratio estimates and the parameter estimates derived from the models in Brownie et al. (1978). The Time Invariant Matrix Model uses average annual survival rates (from data sets in Appendixes B, C, and D), and production rates developed from Duck Wing Collection Survey data for the period 1961–1976 inclusive, in conjunction with a general population projection matrix similar to that developed by Lewis (1942) and Leslie (1945, 1948). This model was used by Martin et al. (1979:215–220) to describe the continental mallard population. Anderson (1975:27–31) used a similar model with minor variations in the expression of production rates and the survival rates of young birds. The model parameters are defined below; the values shown are for New York (122), the data set described in the text.

$\hat{S}_{AM} = 0.5692$ = Average annual survival rate of adult males

$\hat{S}_{AF} = 0.5293$ = Average annual survival rate of adult females

$\hat{S}_{YM} = 0.4152$ = Average annual survival rate of young males

$\hat{S}_{YF} = 0.4430$ = Average annual survival rate of young females

$\hat{P} = 1.1502$ = Average annual recruitment rate or preseason age ratio (young/adult in the fall population)

$R = 0.50$ = Sex ratio of young birds expressed as proportion male

$M_i$ = Number of adult males in year i

$F_i$ = Number of adult females in year i

$Y_i$ = Number of young in year i

The model time period is 1 year, the anniversary date being about mid-August, the mid-point of the preseason banding period. Production rates were estimated by flyways (Atlantic and Mississippi Flyways only) and were averaged to produce a continental rate. A weighted continental production rate also was developed based on recent population size estimates (Spencer 1980). The sex ratio was assumed to be 0.50 in young birds based on reports by Bellrose et al. (1961:403–405), Aldrich (1973: 484–485), and Anderson et al. (1970).

The projection matrix is defined as.

$$A = \begin{bmatrix} S_{AM} & O & RS_{YM} \\ O & S_{AF} & (i\text{–}R)\ S_{YF} \\ PS_{AM} & PS_{AF} & (RPS_{YM} + (1\text{–}R)\ PS_{YF}) \end{bmatrix}$$

The population vector for year i is defined as

$$X_i = \begin{bmatrix} M_i \\ F_i \\ Y_i \end{bmatrix}$$

The basic population model is expressed by the equation $X_{i+1} = A\ X_i$, which is used to step the population vector through time. An iterative procedure (Searle 1966: 181–183) is employed to obtain the dominant eigenvalue $\lambda$, which represents the finite annual growth rate of the population (Martin et al. 1979:217).

Since the long-term average rate of increase for an extant animal population must approach 1.0 (Reddingius and den Boer 1970, *in* Martin et al. 1979:217), I examined the $\lambda$ and age ratio (Production) values derived from New York(122), the most precisely measured preseason data set, to determine how well the model estimate relates to a stable black duck population with an assumed growth rate of $\lambda = 1.0$, ie., the mortality rate of adults equals the recruitment rate of adults. Next the New York(122) data were simulated using an assumed production rate of 1.0 (mallard production rate for the period 1961–1975 was about 1.00–1.03; Anderson 1975:36; Martin et al. 1979:216) to evaluate its effect on $\lambda$. Survival rate adjustments were made based on Anderson's simulation studies to evaluate the accuracy of the Brownie survival estimates.

Anderson (1975:28–29) concluded from simulation tests that Brownie model survival estimates were biased upward by 1% for adults and by 3% for young. The major source of this bias was attributed to the depressed band reporting rate in the vicinity of banding stations (Henry and Burnham 1976). Anderson corrected for the observed bias by using band reporting rate correction factors developed by Henry and Burnham (1976) from the mallard reward band study data.

I have assumed the same survival rate estimate bias exists in the black duck survival estimates. But because

Black Duck Reward Band Study reporting rate correction factors are not yet sufficiently refined to correct individual band recoveries for reporting rate estimates, New York(122) survival rates were reduced by 1% for adults and 3% for young in the projection matrix to remove the positive bias. Initially, the model was run with the adjusted survival rate values and the production rate derived from the Duck Wing Collection Survey. A second model run used a production rate of $P = 1.0$. Similar tests were performed with several other data sets, and two input data sets that represented Continental Black Duck Population parameter estimates were used in the final simulations.

The first continental data set represents a simple average of survival rates and production rate computed from various individual state/province and major reference area data; the second data set uses the same set of survival and production rate values as the first, but they are weighted based on the various reference area population estimates. The population weighting factors used were computed from data in Spencer (1980:7). Average and weighted average production rates were developed from Mississippi and Atlantic Flyway production estimates computed from Duck Wing Collection Survey data and band recovery data (Martin and Carney 1977; Geis 1972a).

Finally, a sensitivity analysis was conducted to determine the effects of small changes in the input parameters ($\pm 10\%$) on the value of $\lambda$. The New York(122) matrix was used with a production rate of 1.1502 (Atlantic Flyway average, 1961–1976).

### *Stochastic Population Model*

Deterministic models such as the matrix model described above may provide reasonable approximations of reality; however, they can be misleading, especially when actual variation is relatively high (Boyce 1977). Therefore, a stochastic model was developed to obtain more realistic inferences about the black duck population. The basic model is specified by the following three difference equations:

$$M_i + 1 = M_i S_{AM,i} + RY_i S_{YM,i}$$

$$F_i + 1 = F_i S_{AF,i} + (1 - R)\, Y_i S_{YF,i})$$

$$Y_i = (M_i F_i)\, P_i$$

where $M_i$, $F_i$ and $Y_i$ are the numbers of adult males, adult females, and young birds (both sexes), respectively, in mid-August of year i; R is the mid-August sex ratio of young birds expressed as proportion males; $S_{AM,i}$, $S_{AF,i}$, and $S_{YF}$ are the annual survival rates of adult males, adult females, young males, and young females, respectively, in year i; and P is the production rate expressed as the ratio of young to adult birds in mid-August of year i. The structure of the stochastic model is therefore very similar to that of the deterministic model. However, in the stochastic model annual production and survival rates are treated as random variables rather than as constant parameters.

In the computer program for the stochastic model, input data included a mean and standard deviation for production rate, a vector ($\hat{\underset{\sim}{S}}$) of mean survival rates (for the four age–sex classes), and a variance–covariance matrix ($\Sigma$) corresponding to the survival rates of the four age–sex classes. Production rates were assumed to be distributed normally, and annual rates were generated as normal deviates with specified mean and standard deviation using an IBM pseudorandom number generator. Survival rates of the four age–sex classes were assumed to be distributed as multivariate normal. Multivariate normal deviates corresponding to the survival rate vector were generated annually by multiplying a vector of independent deviates, each distributed as normal (0,1), by a matrix P, where P is defined such that $P^T P = \Sigma$ (where $P^T$ is the transpose of P). The resulting vector was then added to the mean vector, $\hat{\underset{\sim}{S}}$, to obtain the multivariate deviates.

Data for Eastern Lake Ontario(12), Model H1, were used for a sensitivity analysis, since this data set was superior in quality to other preseason data sets. The input parameter values used in the Stochastic Model were

$\hat{S}_{AM}$ = 0.5872 = average annual survival rate of adult males

$\hat{S}_{AF}$ = 0.5064 = average annual survival rate of adult females

$\hat{S}_{YM}$ = 0.4331 = average annual survival rate of young males

$\hat{S}_{YF}$ = 0.3606 = average annual survival rate of young females

$\hat{P}$ = 1.2265, with variance = 0.0023 = average annual production rate (young/adult).

The production value (P) was derived by adjusting the Atlantic Flyway production value ($\hat{P} = 1.1503$) upward until a stable growth rate ($\lambda = 1.0$) was achieved in conjunction with the survival vector above. Therefore, the initial model run represents a stable population.

The Variance–Covariance Matrix ($\Sigma$) was estimated from survival estimates and is shown below:

$$\Sigma = \begin{bmatrix} 0.0195 & 0.0028 & 0.0048 & 0.0011 \\ 0.0028 & 0.0255 & 0.0092 & 0.0235 \\ 0.0048 & 0.0092 & 0.0122 & 0.0087 \\ 0.0011 & 0.0235 & 0.0087 & 0.0264 \end{bmatrix}$$

The sex ratio of young was assumed to be 1:1 = 0.5. The starting population was set at 50,000 each of adult males and females. Standard values to represent the stable population parameters defined above were computed for each output variable: mean population size; mean number of adult males, adult females, young males, young females; mean production rate (age ratio); mean sex ratio; and arithmetic and geometric mean rates of change in the population growth rate. To do this, five 50-year simulations were run using the initial input data. A different starting number was used in the pseudorandom number generator program for each of the five simulations. The five values obtained for each output variable then were averaged to provide the set of output variable standard values.

The sensitivity analysis was performed by following the procedure described above, including the use of the same five starting numbers in the pseudorandom number generator program. This reduced variability in the output values caused by randomness. Each sensitivity experiment consisted of making a small change ($\pm 10\%$) in one or more input values (e.g., changing the adult male survival rate from 0.5872 to 0.5284, a $-10\%$ change) and then comparing the averages of all the output values with the standard values to measure the effects of the change.

The series of experiments performed with the deterministic model was repeated using the stochastic model. However, each experiment consisted of 10 50-year simulations, each with a different starting number employed in the pseudorandom generator. The 10 initial values were not repeated for later tests since the 10-run average simulation values showed low variability in preliminary tests. This group of experiments included a sensitivity analysis, the correction for positive bias of survival estimates, modification of the production rate to a level at which adult mortality is compensated for by recruitment (P = 1.0), determination of the magnitude of changes required in $\underset{\sim}{S}$ and P to produce a stable population growth rate ($\lambda = 1.0$), and examination of average and weighted average continental black duck survival and production estimates. An example of the simulation output appears in Appendix Table L-1.

Two final simulation series were run. Data sets for Quebec, Ontario, Maine, and New York, the only state preseason data sets with adequate banding for each age–sex class, were used to describe the behavior of those state/province survival and production estimates in the model and to compare their respective population curves and growth rates with what is known or implied from empirical data. In addition, New York(122) data were used in a third sensitivity analysis to provide a comparison with its counterpart in the deterministic model sensitivity analysis.

# Results

## *Time Invariant Matrix Model*

The deterministic Time Invariant Matrix Model was used to test the internal consistency of the parameter estimates, and to validate those estimates in the sense that model outputs represented realistic values with respect to empirical field data.

The dominant eigenvalue $\lambda$ and its corresponding eigenvector $\underset{\sim}{\nu}$ describe the asymptotic behavior of the population Lambda ($\lambda$) represents the finite growth rate of the population. If $\lambda = 1$ a steady state results. If $\lambda > 1$, $\nu_i$ diverges and the elements become infinite. Extinction results if $\lambda < 1$ (Anderson 1975:28; Searle 1966:181). Therefore, $\lambda > 1$ occurs only when recruitment exceeds mortality, and $\lambda < 1$ occurs only if mortality exceeds recruitment.

The results of 10 experiments are presented in Table 40. Survival data were derived from various reference

Table 40. *Value of $\lambda$ (finite growth rate) and the population sex ratio (male/female) for eight reference areas and the Continental Black Duck Population.*

| Reference areas | $\lambda$ Value | Sex ratio |
|---|---|---|
| New York (122) | 1.04 | 1.02 |
| S Que (041) | 1.08 | 0.94 |
| E Lk Ont (12) | 1.05 | 1.11 |
| W Lk Ont (13) | 1.13 | 0.96 |
| Maine | 1.10 | 1.31 |
| New York | 1.08 | 1.14 |
| Ontario | 1.08 | 1.35 |
| Quebec | 1.08 | 1.03 |
| Continental population (ave. rates) | 1.09 | 1.24 |
| Continental population (wgt. ave. values) | 1.06 | 1.27 |

areas (Appendixes B–D). The production values used were 1.150 for the Atlantic Flyway, 1.128 for the Mississippi Flyway, and 1.139 and 1.147, respectively, for the Continental average and weighted average Black Duck Populations as derived from the Duck Wing Collection Survey data corrected for annual differential vulnerability to hunting. Anderson (1975:36) reported an average of 1.0 young pet adult (1961–1970) for mallards based on similar banding and harvest data sources. Martin et al. (1979:230) show mallard recruitment rates that range between 0.7 and 1.5 young per adult over the period 1967–1977, and average 1.0 Newell and Boyd (1978:92) reported 9-year mean age ratios for black ducks ranging from 1.91 to 2.58 young/adult in Canada, or 1.0 to 1.3 young per adult female.

It is evident from the λ values shown in column 2, Table 40, that if the parameter estimates used were the actual population parameter values each population would be increasing. The rate of growth ranges from 4% to 13% annually. Anderson (1975:28–29) obtained similar results using mallard data. Correction for the positive bias in survival estimates identified by Anderson (–1% for adults, –3% for young; 1975:28) resulted in an average 2% reduction in λ. No substantial change occurred in the population sex ratio.

Martin et al. (1979:217) computed $\lambda = 1.24$ for mallards covering the period 1961–1974. The authors expressed concern about the considerable divergence of the finite growth rate λ from 1.0. By using a year-specific projection model they determined that their survival rate estimates must be reduced by 21% or their recruitment rate estimates by 42% to yield population values comparable to those obtained for mallards using annual breeding grounds survey data (Pospahala et al. 1974).

I applied the same method on three data sets (New York(122), Average Continental Black Duck Population, and Weighted Average Continental Black Duck Population), which also were used in the stochastic models. Survival rate reductions of 4%, 8%, and 5%, respectively (Table 41, column 6), or production rate reductions of 9%, 17% and 12%, respectively, were required to produce a population steady state ($\lambda = 1.0$; Table 41, column 7).

The three data sets above, under the assumption of a production rate of P = 1.0 and using survival rates either unadjusted or adjusted for positive bias produced the results shown in columns 2 and 3, respectively, in Table 41. If the production rate of New York(122) was about 1.0, then a declining population in that minor reference area is indicated. The continental population models appear to be nearly stable.

The final examination of the Continental Black Duck Population data sets involved the computation of λ and the adult preseason sex ratio under the assumption of a production rate equal to 1.0 using both the initial and the adjusted survival rate values (average and weighted) as input parameters. The purpose of the simulations was to test the internal consistency of the model by evaluating the sex ratio output values compared to sex ratio estimates from Harvest Survey data. The results are discussed below.

## Sex Ratio

The right eigenvector $\underset{\sim}{v}$ associated with λ ultimately defines the structure of the modeled population (Martin

Table 41. *Changes in the finite growth rate (λ) and the population sex ratio associated with adjustments in the survival rate ($\hat{S}$) and the production rate ($\hat{P}$) for various black duck data sets, and the reduction in $\hat{S}$ and $\hat{P}$ required to reach population stability (λ = 1.0—Deterministic Model).*

| Reference area | $\hat{S}$ Unadjusted P = 1.0 | | $\hat{S}$ Adjusted* P = 1.0 | | % Reduction in survival rates ($\hat{S}$) | % Reduction in production rates ($\hat{P}$) |
|---|---|---|---|---|---|---|
| | λ | S/R | λ | S/R | | |
| New York (122) | 0.98 | 1.03 | 0.96 | 1.03 | 4 | 9 |
| Continental Black Duck Population—average parameter values | 1.02 | 1.23 | 1.01 | 1.24 | 8 | 17 |
| Continental Black Duck Population—weighted average parameter values | 1.00 | 1.26 | 0.98 | 1.27 | 5 | 12 |

*$\hat{S}$ adjustment = –1% for adults, –3% for young.

et al. 1979:217). The computed value of $\underset{\sim}{v}$ for the Continental Black Duck Population (using average survival rates and production rate) was $\underset{\sim}{v}$ = (0.553, 0.447, 1.000). This corresponds to the dominant eigenvalue $\lambda$ which = 1.01. The asymptotic adult sex ratio obtained from the the first two elements of the eigenvector (0.533/0.447) = 1.24 males per female in the preseason black duck population (Table 41). Corresponding values with weighted survival rates and production rate data are $\underset{\sim}{v}$ = (0.558, 0.441, 1.000) and $\lambda$ = 0.98. The asymptotic adult sex ratio is 1.27 (Table 41). Using the method of Wight et al. (1965) to compute the adult sex ratio provided estimates of 1.20 males per female (average values) and 1.23 males per female (weighted average values).

Modeling studies by Anderson (1975a:32) produced adult male per adult female sex ratios of 1.21 (by method of Wight et al. 1965) and 1.27 for North American mallards (simulation results). Johnson and Sargeant (1977:21) derived a spring adult sex ratio of 1.26, and indicated that their stochastic model confirmed a more highly distorted fall (preseason) sex ratio. Martin et al. (1979:217–218) examined mallard data covering the period 1961–1974 to compute a sex ratio of 1.35 adult males per adult female.

I used band recovery and Harvest Survey data for the period 1961–1976 to adjust the black duck sex ratio in the harvest to correct for differential vulnerability to hunting of either sex (Anderson et al. 1970; Geis 1972b). The computed sex ratio estimate was 1.27, the same value reported by Crissey (n.d.). Martin et al. (1979:218) computed a mallard sex ratio of 1.39 adult males per adult female using the same method. Although the sex ratio estimate computed in this study from empirical data is substantially lower than the mallard estimates presented, the asymptotic sex ratios derived from the model (Table 41, columns 3 and 5) agree closely with this estimate and indicate a high degree of internal consistency in the model. Bias correction and adjustments to the survival rate estimates had only a slight effect on the sex ratio.

### Survival

The average survival values used in the Continental Black Duck Model for young birds (44%—YM, 44%—YF) are less than the average values for the mallard (50%—both sexes) reported by Anderson (1975:32), indicating that young black ducks do not survive as well. His bias-adjusted survival estimates (1975:31), reported as 48% for young males and 46% for young females, correspond to the bias-adjusted young black duck survival estimates of 43% for young males and 41% for young females. The weighted survival rate values are not comparable to Anderson's data, which were not weighted. The values for weighted average survival estimates adjusted for positive bias (−3% for young survival rates) are 41% for young males and 40% (rounding error) for young females. Adult survival rates were approximately 63% for males and 53% for females, depending on the data set used. These are similar to adult mallard survival rates.

## *The Stochastic Model*

Eastern Lake Ontario(12), Model H1 was selected for the sensitivity analysis because it is the best preseason banding data set. The major reference area includes most of upstate New York and southeastern Ontario. Considerable movement of black ducks occurs between the two minor reference areas (Files, Office of Migratory Bird Management). A significant proportion of the black ducks produced in each area (15%−20%) is harvested in the other.

### Sensitivity analysis

Results of the sensitivity analysis are shown in Table 42. Two response values are given for each adjusted standard value. The first value for a given change represents the percent change in the new output variable compared to the output variable observed under the initial model conditions. For example, a change of +10% in the adult male survival rate produced a +277% change in the size of the black duck population over a 50-year period, compared to the size of the population produced over the same time period using the adult male survival rate computed by the Brownie model (Brownie et al. 1978:56).

The second response value represents the ratio of relative change in the output variable to the relative change in the input parameter as defined by Johnson and Sargeant (1977:15) and expressed below:

$$\frac{\text{altered output value} - \text{standard output value}}{\text{standard output value}}$$

divided by

$$\frac{\text{altered input value} - \text{standard input value}}{\text{standard input value}}$$

Large response values indicate that the output variable under consideration is sensitive to small changes in the input parameter. In the example for adult males above, the total population response value of 33% means that a +10% variation in the input parameter caused a change of one-third that amount (3.3%) in the output variable. The

Table 42. *Changes in population size and in population parameter values (Stochastic Model[1]) resulting from fixed changes in the input parameters.[2]*

| Standard | Total population Average | Total population Response | Adult males (AM) Average | Adult males (AM) Response | Adult females (AF) Average | Adult females (AF) Response | Young males (YM) Average | Young males (YM) Response | Young males & females Average | Young males & females Response | Sex ratio[5] Average | Sex ratio[5] Response | Growth rate Average | Growth rate Response |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | % | | % | | % | | % | | % | | % | | % |
| AM $\hat{\hat{S}}$ | | | | | | | | | | | | | | |
| +10 | 3,293,460 | 277[3] | 915,081 | 274 | 570,028 | 217 | 903,815 | 217 | 1,807,631 | 287 | 161.3 | +6.7 | 1.060 | 3.0 |
| | | 33[4] | | 32 | | 25 | | 26 | | 34 | | 0.8 | | 0.4 |
| −10 | 403,345 | −54 | 103,648 | −58 | 77,818 | −57 | 110,940 | −61 | 221,880 | −52 | 137.6 | −9.0 | 0.994 | −3.0 |
| | | 6 | | 7 | | 10 | | 7 | 6 | | | +1.1 | | 0.4 |
| AF $\hat{\hat{S}}$ | | | | | | | | | | | | | | |
| +10 | 1,835,856 | 110 | 472,460 | 93 | 354,758 | 97 | 504,319 | 77 | 1,008,638 | 116 | 136.9 | −9.5 | 1.058 | 3.0 |
| | | 11 | | 9 | | 10 | | 8 | | 12 | | −1.0 | | 0.1 |
| −10 | 579,005 | −34 | 161,296 | −34 | 99,364 | −45 | 159,173 | −44 | 318,346 | −32 | 168.8 | +11.6 | 1.008 | −2.0 |
| | | 3 | | 3 | | 5 | | 4 | | 3 | | −1.2 | | 0.2 |
| YM $\hat{\hat{S}}$ | | | | | | | | | | | | | | |
| +10 | 2,300,931 | 163 | 637,406 | 160 | 399,853 | 122 | 631,837 | 122 | 1,263,674 | 171 | 162.9 | +7.7 | 1.051 | 3.0 |
| | | 18 | | 17 | | 13 | | 13 | | 18 | | 0.8 | | 0.3 |
| −10 | 473,191 | −46 | 121,703 | −50 | 91,220 | −49 | 130,134 | −54 | 260,268 | −44 | 137.0 | −9.4 | 1.002 | −2.0 |
| | | 3 | | 3 | | 3 | | 3 | | 3 | | 1.0 | | 0.1 |
| YF $\hat{\hat{S}}$ | | | | | | | | | | | | | | |
| +10 | 1,669,478 | 91 | 431,962 | 76 | 320,300 | 78 | 458,608 | 61 | 917,216 | 97 | 138.6 | −8.3 | 1.041 | 2.0 |
| | | 11 | | 9 | | 9 | | 7 | | 12 | | −1.0 | | 0.2 |
| −10 | 600,885 | −31 | 167,281 | −32 | 103,216 | −43 | 165,193 | −42 | 330,386 | −29 | 166.0 | +9.8 | 1.009 | −2.0 |
| | | 4 | | 4 | | 5 | | 5 | | 4 | | −1.2 | | 0.2 |
| Age ratio | | | | | | | | | | | | | | |
| +10 | 5,016,534 | 474 | 1,264,997 | 417 | 879,135 | 388 | 1,436,201 | 405 | 2,872,402 | 516 | 149.1 | −1.4 | 1.071 | 4.0 |
| | | 21 | | 19 | | 17 | | 18 | | 23 | | −0.1 | | 0.2 |
| −10 | 244,991 | −72 | 69,743 | −72 | 46,914 | −74 | 64,167 | −77 | 128,934 | −72 | 154.4 | +2.1 | 0.980 | −4.0 |
| | | 7 | | 7 | | 7 | | 8 | | 7 | | −0.2 | | 0.4 |
| AM & AF $\hat{\hat{S}}$ | | | | | | | | | | | | | | |
| +10 | 6,256,361 | 616 | 1,681,410 | 587 | 1,138,990 | 533 | 1,717,980 | 504 | 3,435,960 | 636 | 150.3 | −0.6 | 1.084 | 6.0 |
| | | 67 | | 64 | | 58 | | 55 | | 70 | | −0.1 | | 0.6 |
| −10 | 241,233 | −72 | 64,280 | −74 | 44,229 | −75 | 66,362 | −77 | 132,724 | −72 | 152.1 | +0.6 | 0.975 | −5.0 |
| | | 8 | | 8 | | 8 | | 8 | | 8 | | −0.12 | | 0.5 |

Table 42. *Continued.*

| Standard | Total population Average | Total population Response | Adult males (AM) Average | Adult males (AM) Response | Adult females (AF) Average | Adult females (AF) Response | Young males (YM) Average | Young males (YM) Response | Young males & females Average | Young males & females Response | Sex ratio[5] Average | Sex ratio[5] Response | Growth rate Average | Growth rate Response |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | % | | % | | % | | % | | % | | % | | % |
| YM & YF $\hat{\hat{S}}$ | | | | | | | | | | | | | | |
| +10 | 4,037,265 | 362 | 1,078,709 | 340 | 742,252 | 312 | 1,108,152 | 289 | 2,216,304 | 375 | 149.4 | −1.2 | 1.068 | 4.0 |
| | | 41 | | 39 | | 36 | | 33 | | 43 | | −0.1 | | 0.5 |
| −10 | 290,611 | −67 | 77,861 | −68 | 52,876 | −71 | 79,937 | −72 | 159,864 | −66 | 153.2 | +1.3 | 0.982 | −4.0 |
| | | 8 | | 8 | | 8 | | 8 | | 7 | | −0.1 | | 0.5 |
| All $\hat{\hat{S}}$ | | | | | | | | | | | | | | |
| +10 | 23,549,539 | 2,595 | 6,273,352 | 2,462 | 4,364,485 | 2,325 | 6,455,841 | 2,169 | 12,911,682 | 2,667 | 148.8 | −1.6 | 1.118 | 9.0 |
| | | 289 | | 275 | | 259 | | 242 | | 298 | | −0.2 | | 1.0 |
| −10 | 91,987 | −89 | 24,121 | −90 | 17,442 | −90 | 25,211 | −91 | 50,422 | −89 | 155.0 | +2.5 | 0.924 | −10.0 |
| | | 10 | | 10 | | 9 | | 9 | | 9 | | −0.3 | | 1.0 |
| | 873,939[1] | | 244,906[1] | | 179,996[1] | | 284,523[1] | | 466,603[1] | | 151.2[1] | | 1.025 [1] | |

[1]Input standard values.
[2]Input parameter values: Eastern Lake Ontario (12); AM = 0.5872, AF = 0.5564, YM = 0.4331, YF = 0.3606, sex ratio = 0.5000 young males per young females, age ratio 1.1502.
[3]Percent change from standard value.
[4]Percent change as a measure of the influence of the input parameter on the output variable (Johnson and Sargeant 1977).
[5]Expressed as the number of adult males per 100 adult females.

response indicates that this variable is more sensitive to small changes than were the adult female or the young male or female input parameters. The age ratio input value also was more sensitive to change than the other three age–sex classes. The combined effect of two or more survival rate input values usually caused response values greater than any single input parameter value change.

The adult male per adult female sex ratio showed only small changes from the output standard value of 1.51 (151.2 adult males per 100 adult females); no change exceeded 4%. The response value relative to the change in the input parameter values never exceeded ±0.4%. The sex ratio is relatively insensitive to small changes in input parameter values. Johnson and Sargeant (1977:16–17) obtained similar results in their evaluation of the effects of small changes in input parameters on the spring sex ratio of mallards. However, they did conclude that the sex ratio in their model depended solely upon survival rate values even though small changes in those values had little effect on the sex ratio. This conclusion applies to the present study.

The growth rate ($\lambda$) also was insensitive to small changes in the input parameter values. Response values relative to the standard growth rate output value ranged from 2.0% to 9.0% for + 10% changes in the input parameter values, and from –10% to 1.0% for –10% changes in the input parameter values. Except for the case where all input survival rate values changed by ±10%, the growth rate remained at about $\lambda = 1.0$ or slightly higher, indicating a relatively stable population.

The sensitivity analysis was re-examined to show graphically the effects of 10% changes in the input parameter values. Minor reference area New York(122) was selected for the analysis because it provides the most precise U.S. preseason survival estimates. This is the same data set used in the Invariant Matrix Model sensitivity analysis. The input parameter values used were:

0.5692 = adult male survival rate

0.5293 = adult female survival rate

0.4152 = young male survival rate

0.4430 = young female survival rate

Other model inputs are the same as described under Methods. The results were plotted on a logarithmic scale to accommodate the range in population size. Each curve displayed in Figures 4 and 5 represents the average of 10 50-year simulations of a particular set of input parameter values. The ±10% changes are equivalent to those made in the previous simulation experiment. The three curves in each graph represent: (1) the population curve derived from unadjusted survival rate estimates (Brownie et al. 1978) and the Atlantic Flyway production estimate, (2) the data as in (1) except for a + 10% change in the input parameter value(s) as specified in the graph title, and (3) the data as in (1) except for a –10% change in the input parameter value(s) as specified in the graph title.

The results are similar to those from the sensitivity analysis of Eastern Lake Ontario (12) data. A 10% increase in the survival rate of males showed the greatest response relative to population size. Figure 4 shows a total population after 50 years of about 7 million black ducks, whereas adult females and young, with similar increase in survival rate, resulted in a final population size of 4 to 4.5 million black ducks. A negative change (–10%) in survival rate also produced the greatest response when applied to adult males. A 10% reduction in adult male survival rate resulted in a final population size of less than 4 million birds, while the other three age–sex classes, with similar survival rate reductions, maintained populations above 4 million birds. The young male black duck response produced about 0.5 million more birds than did young females. Therefore, the change in survival rates of adult females and young produced essentially the same results.

Changes in more than one age–sex class concurrently are shown in Figure 5. Clearly, the greatest response results from a similar, concurrent change in all age–sex classes. In 28 years with a + 10% change the simulated population expanded from 200,000 birds to 10 million birds, a rate of increase much greater than that produced by modifications in the other input parameters, singly or combined. The effects of small negative impacts also are more dramatic when all age–sex classes are affected.

Small changes in any two input survival parameters (adults or young) produced substantial changes, too. In both cases shown in Figure 5, populations exceeded 10 million birds in less than 50 years ( + 10% change) or declined to about 100,000 birds in 50 years (–10% change). When only one input parameter was changed (Figure 4), populations increased to levels of 4 to 7 million ( + 10% change) or declined to levels of 3.5 to 4.5 million (–10% change). The effects of changes in the age ratio (10%) also are shown in Figure 5. The results are nearly identical to the corresponding chan s made either in the adult survival rates combined or in the young survival rates combined.

## Validation of Parameter Estimates

Survival rate estimates for Ontario, Quebec, New York, and Maine were simulated to evaluate their perfor-

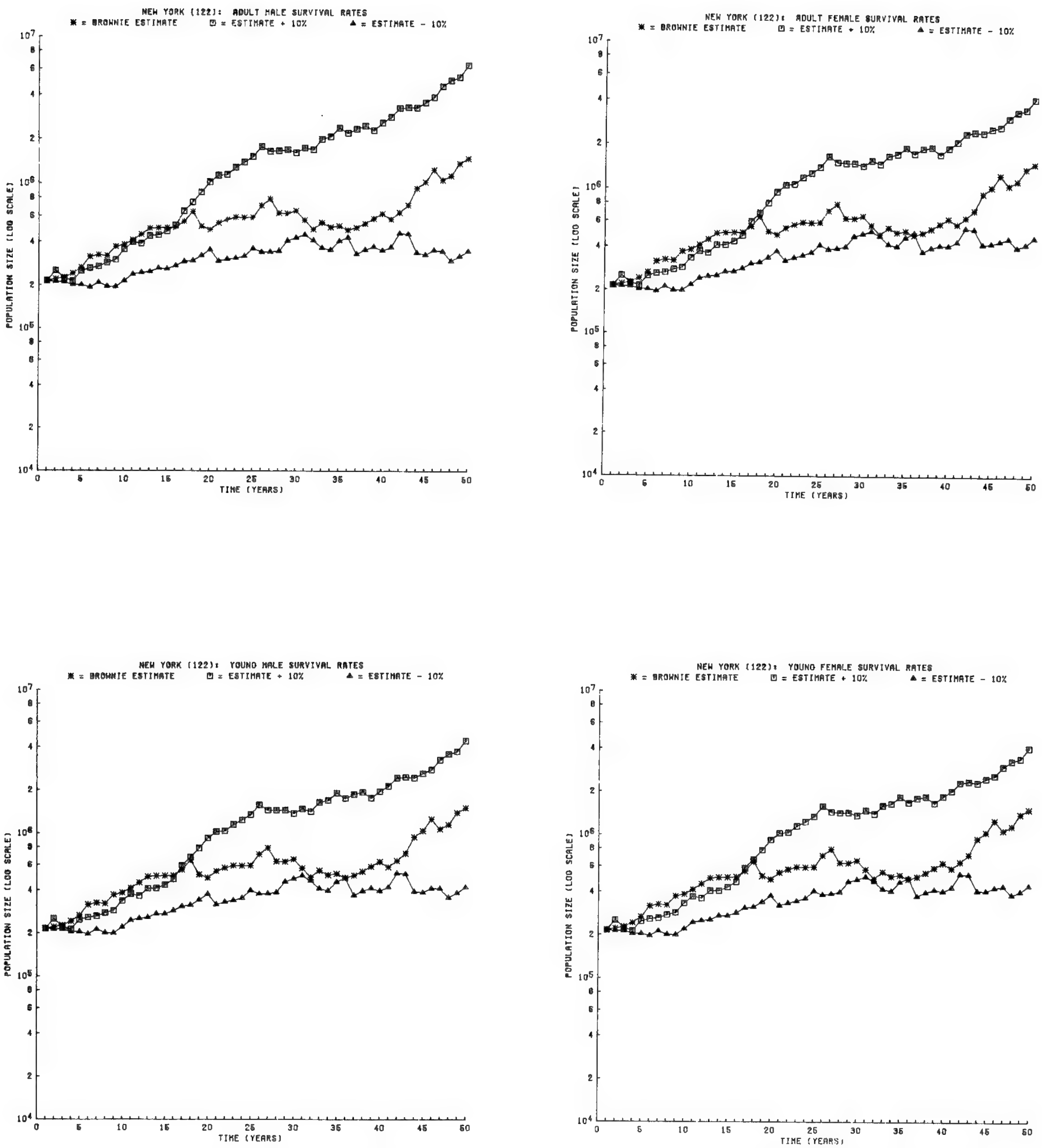



**Figure 4.** The effects on a black duck population—New York (122)—of fixed rates of change (±10%) on various input parameter values. Input survival estimates were derived from models in Brownie et al. 1978. Production estimates were derived from parts collection survey data, 1961–1976 (Martin and Carney 1977). Each curve represents the average of 10 50-year simulations by the stochastic model described in the text.

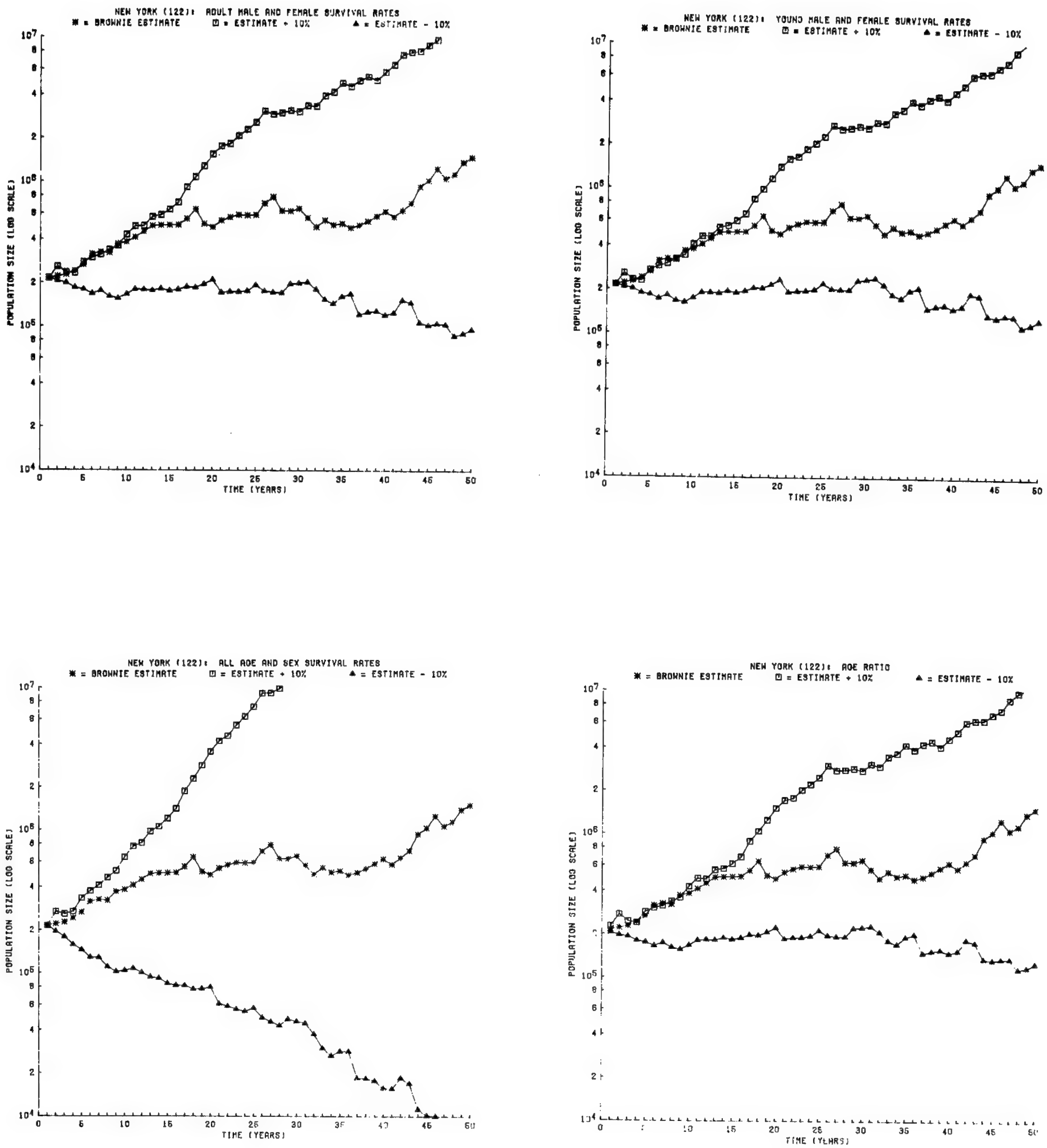



**Figure 5.** The effects on a black duck population—New York (122)—of fixed rates of change (±10%) on various input parameter values. Input survival estimates were derived from models in Brownie et al. 1978. Production estimates were derived from parts collection survey data, 1961–1976 (Martin and Carney 1977). Each curve represents the average of 10 50-year simulations by the stochastic model described in the text.

mance with respect to population growth, and to relate their performance to other information sources concerning black duck population trends. Adjustments were made to correct for survival rate overestimation bias as described previously. Finally, the data sets were run with an assumed production rate of 1.0 and with average survival rate and production rate values (Atlantic and Mississippi Flyways—U.S. portions) computed using state/provincial survival rate estimates. The results are shown in Table 43 for values of λ and the adult sex ratio and are plotted (logarithmic scale) in Figure 6. Substantial population growth is indicated for each data set based on the results from the unadjusted Brownie survival rate estimates. Correction for a positive bias in the estimates reduced λ slightly, but a relatively high growth rate remained evident in all cases. The simulations with P = 1.0 appear realistic, but not in conformance with other data sources (Files, Office or Migratory Bird Management) that suggest a stable black duck population at best, or a declining black duck population (–2%/yr. based on Winter Survey data). However, regional differences in the population status of the black duck throughout its range are to be expected in a dynamic system in which external influences vary from place to place and temporally.

A continental black duck population was simulated in the manner described for the state/province experiments. The same procedures also were used to simulate a continental black duck population using weighted survival and production rate values, but with an additional run in which survival rates were corrected for positive bias and applied to a population with P = 1.0. Weighting factors were derived from Spencer (1980:7). The population estimates are crude, based on limited production surveys related to various habitat types, and extrapolated using the product of the acreage value for each habitat type and its black duck productivity value. However, the proportionate distribution of breeding black ducks appears to be reasonable and the weighting factors give more importance to survival rate values of those areas with the largest black duck breeding populations.

Average Continental Black Duck Population survival rate and age ratio values are examined first. Values for λ and the male per adult female sex ratio (S/R) are shown in Table 44. The simulated population curves are shown in Figure 7. The original Brownie estimates and the adjusted survival rates both indicate rapid population growth (λ = 1.06, λ = 1.05, respectively). Reduction of the production rate to P = 1.0 reduced the growth rate to λ = 1.0, a condition of population stability. The correction for positive bias in survival rate estimates in conjunction with P = 1.0 also yielded a stable growth rate, λ = 0.99. The same adjustments produced a λ value of 0.96 when applied to the weighted average annual survival and production rates of the Continental Black Duck Population. This agrees closely with the trend of long-term population estimates derived from the Winter Survey which indicates a 2% annual rate of decrease.

The average sex ratio values of 1.22 and 1.25 which relate to the average and weighted average survival and production rate values respectively agree closely with the sex ratio estimates of 1.24 and 1.27 derived from the deterministic model. In addition, the simulated estimates are in close agreement with the sex ratio estimate of 1.27, computed from band recovery data and the Duck Wing Collection Survey data. Adjustments to the input parameters to correct for positive bias in the survival rate estimates yielded higher sex ratio estimates (1.34, 1.38; average and weighted average values) as did the added assumption of P = 1.0 (1.32, 1.35; average and weighted average values).

The final simulation experiment provided a measurement of the amount of change required in the unaltered Brownie estimates and in the production rate estimate to bring the population growth rate, λ, to a stable condition.

Table 43. *Changes in the finite growth rate (λ) and the population sex ratio (S/R) associated with adjustments in the survival rate ($\hat{S}$) and the production rate ($\hat{P}$) for four state/province reference areas (Stochastic Model).*

| Reference areas | $\hat{S}$ and $\hat{P}$ Unadjusted | | $\hat{S}$ Adjusted* $\hat{P}$ Unadjusted | | $\hat{S}$ Unadjusted P = 1.0 | |
|---|---|---|---|---|---|---|
| | λ | S/R | λ | S/R | λ | S/R |
| Ontario | 1.06 | 1.36 | 1.05 | 1.45 | 1.00 | 1.49 |
| Quebec | 1.06 | 1.05 | 1.05 | 1.12 | 1.00 | 1.15 |
| New York | 1.06 | 1.16 | 1.04 | 1.23 | 0.99 | 1.27 |
| Maine | 1.08 | 1.32 | 1.07 | 1.40 | 1.02 | 1.46 |

*$\hat{S}$ adjustment = –1% for adults, –3% for young.

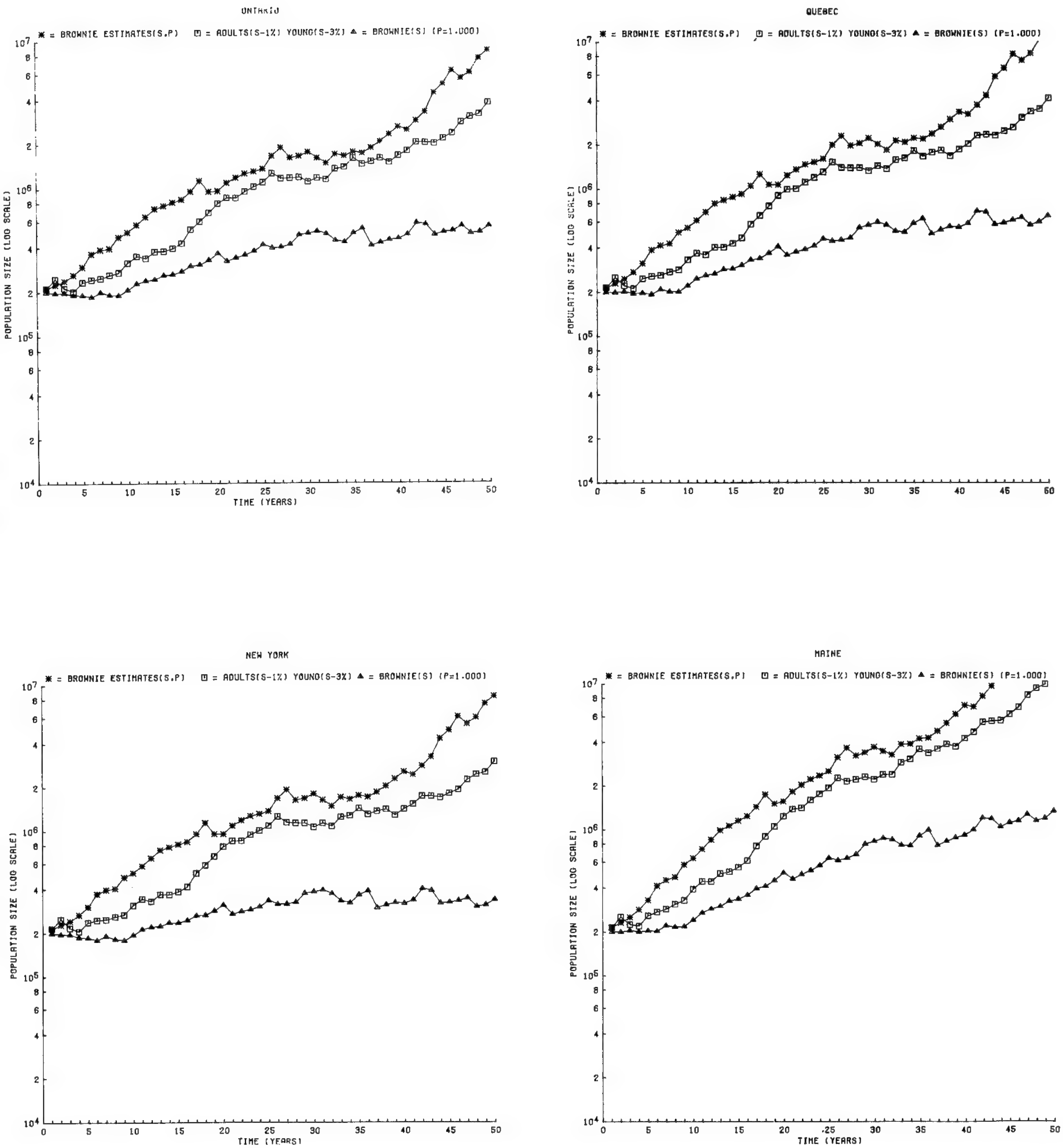



**Figure 6.** State/province populations. Input survival estimates were derived from models in Brownie et al. 1978. Production estimates were derived from parts collection survey data, 1961–1976 (Martin and Carney 1977). Data modifications are explained in the text. Each curve represents the average of 10 50-year simulations by the stochastic model described in the text.

Table 44. *Changes in the finite growth rate (λ) and the population sex ratio (S/R) associated with adjustments in the survival rate ($\hat{S}$) and the production rate ($\hat{P}$) for the Continental Black Duck Population (Stochastic Model).*

| Data set | $\hat{S}$ and $\hat{P}$ Unadjusted | | $\hat{S}$ Adjusted* $\hat{P}$ Unadjusted | | $\hat{S}$ Unadjusted P = 1.0 | | $\hat{S}$ Adjusted* P = 1.0 | |
|---|---|---|---|---|---|---|---|---|
| | λ | S/R | λ | S/R | λ | S/R | λ | S/R |
| Continental Black Duck Population—average parameter values | 1.06 | 1.22 | 1.05 | 1.30 | 1.00 | 1.34 | 0.99 | 1.32 |
| Continental Black Duck Population—weighted average parameter values | 1.03 | 1.25 | 1.02 | 1.33 | 0.97 | 1.38 | 0.96 | 1.35 |

*$\hat{S}$ adjustment = –1% for adults, –3% for young.

Each state data set presented above and the two continental population data sets were examined. The results presented in Table 45 show that substantially smaller adjustments were required in the black duck input parameters to reach population stability than were required by Martin et al. (1979:221) for mallards to achieve a population curve similar to one projected from breeding grounds survey data (–21% for survival rates, –42% for $\hat{P}$; Anderson (1975:32) believed that for the mallard population P = 1.0).

Clearly, the production rates or survival rates or both appear to be too high. Based on Anderson's (1975:28) simulation work with survival estimate biases, and the reported production rate of mallards ($\hat{P}$ = 1.0) derived from the Duck Wing Collection Survey and band recovery data, I believe that the black duck production rates for the Atlantic Flyway ($\hat{P}$ = 1.150) and the Mississippi Flyway ($\hat{P}$ = 1.128) overestimate the true parameter value, or if the production estimates are reasonable, then the mortality of young is great enough to restrict population growth. In fact, both conditions, i.e., overestimation of production and excessive mortality of young, at least locally, probably exist.

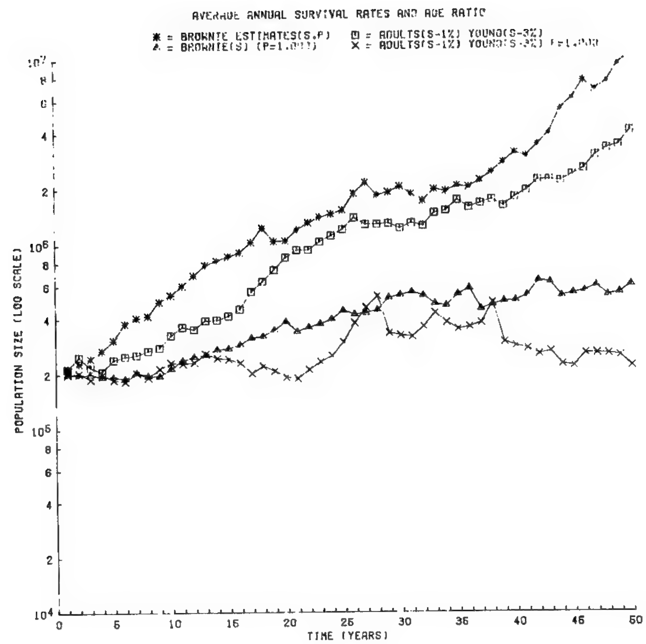
## Discussion

Estimates of the adult sex ratio computed by the Invariant Matrix Model closely approximated empirical sex ratio estimates based on unadjusted Duck Wing Collection Survey data. However, the λ values are reasonable and consistent with our limited knowledge of black duck population status only if certain positive bias correction factors are used.

The stochastic model results (using bias correction factors) agree closely with expectations based on empirical data. However, the results represent only one expression of the model precess from an infinite array of simulations. It is an easy step for the unwary to equate model results with actual conditions, and to transfer those results to the population in question.

Although the stochastic model sex ratio estimates are in close agreement with the empirical estimates (1.22 and 1.25 vs. 1.27 for average and weighted average Continental Black Duck Population data), the range of values computed by the model was substantially greater than was observed from survey data. The extremes observed in the unadjusted Duck Wing Collection Survey data were 0.78 to 2.26 adult males per adult/female. Model results (with data corrected for positive bias in survival rate estimates) ranged from 0.51 to 5.37 adult males per adult female using unweighted average data for the continental population, and 0.65 to 5.05 adult males per adult female using weighted average data. Thus, the model computed nearly the same mean sex ratio, but the individual estimates were more variable than those computed from Harvest Survey data. This is explained in part by the magnitude of the entries in the Variance–Covariance Matrix (Σ) of the model. Anderson (1975:35) derived a variance–covariance matrix for mallards whose entries were substantially smaller than those used in this study. I used his matrix in conjunction with the Eastern Lake Ontario(12) data to evaluate the effect on λ of the much larger variance–covariance entries. The finite growth rate (λ) was insensitive to the larger variance–covariance values. A difference of 0.005 in λ was observed. However, the sex ratio estimates showed greater sensitivity to the variance–covariance matrix. The difference in the sex ratio estimates was 0.10 (1.51, this study; 1.41, Anderson 1975:35). I concluded that part of the greater variability in the observed sex ratio estimates was related to the input Matrix Σ values.

No attempt was made to estimate black duck popula-



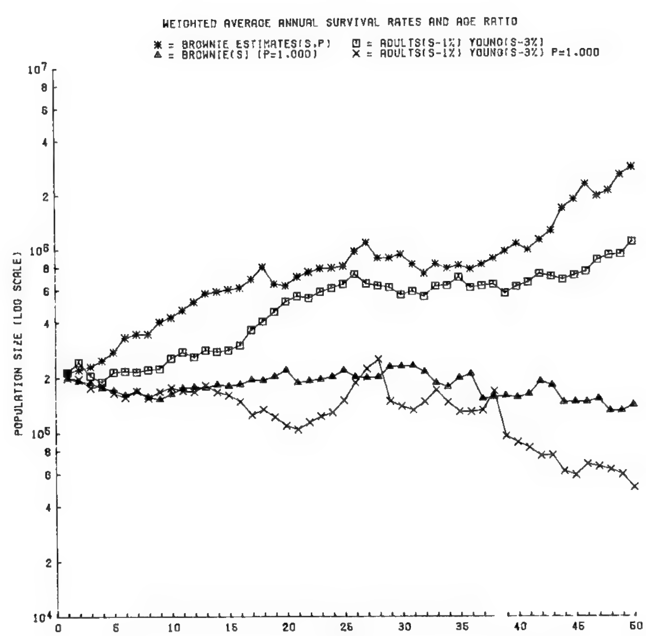




**Figure 7.** Continental black duck population. Input survival rates (Brownie et al. 1978) are estimates averaged across regions and years. The production estimate was derived from parts collection survey data, 1961–1976 (Martin and Carney 1977). Each curve represents the average of 10 50-year simulations by the stochastic model described in the text.

Table 45. *Reduction in survival rate ($\hat{S}$) or production rate ($\hat{P}$) required in various black duck data sets to reach population stability (= 1.0—Stochastic Model).*

| Data set | % Reduction in survival rates | % Reduction in production rates |
|---|---|---|
| Ontario | 14 | 31 |
| Quebec | 5 | 13 |
| Maine | 7 | 15 |
| New York | 4 | 10 |
| Continental (ave.) | 8 | 17 |
| Continental (wgt. ave.) | 5 | 12 |

tion size using the stochastic model. However, population trends projected by the model under various assumptions related to the input parameter values (Figure 7) provide some insight into the accuracy of certain harvest survey estimates. Again, such comparisons are made under the assumption that the model, as adjusted for various biases, correctly mimics the real black duck population. If those parameter adjustments are correct, in particular the production rate adjustment, then the model results for the weighted average continental population closely follow the trend of empirical data derived from the Winter Survey. It is important to note that the Winter Survey data contain many biases and are extremely variable. Consequently, the survey does not necessarily project a realistic view of black duck population status.

## Summary

1. The preseason sex ratio of adults is estimated to be 1.27 males per female based on Duck Wing Collection survey data. Simulation tests using a deterministic model produced sex ratio estimates of 1.24 adult males per adult female with unweighted continental black duck population survival and production data, and 1.27 adult males per adult female using weighted continental black duck population data. Corresponding sex ratio estimates for the continental black duck population derived from simulation experiments using a stochastic model were 1.22 and 1.25 adult males per adult female, respectively.
2. Based on simulation results, the black duck population in each reference area studied showed a positive finite growth rate ($\lambda$). Values for $\lambda$ ranged from 1.04 to 1.13. Lambda ($\lambda$) values for the continental black duck population using average and weighted average survival and production rates were 1.06 and 1.03, respectively.
3. Input parameter values (survival and production rates) were adjusted to correct for positive bias in the survival estimates and to evaluate population trends with an assumed production rate of P = 1.0. The growth rate ($\lambda$) values remained in the range of 1.04 to 1.07 when only the survival rate adjustment was made using state/province data from Ontario, Quebec, New York, and Maine. The assumption that P = 1.0 in combination with the survival rate correction produced essentially stable populations in the four data sets. Similar experiments with the continental data sets suggested that $\lambda$ is approximately 1.0, or in the case of the weighted continental black duck population data, below 1.0 (0.96). This suggests that if the model is an accurate representation of the black duck population, and if the bias corrections and the assumption of P = 1.0 are valid data adjustments, then the black duck population is decreasing at the rate of about 4% annually.
4. Indirect population estimates derived by another procedure but also using harvest survey and band recovery data suggest that the continental black duck population is stable. The Winter Survey indicates a population decline of about 2% annually. Neither of these indicators is measured accurately, but both imply that the $\lambda$ values derived in the simulation models by using the unadjusted Brownie estimates and the Waterfowl Parts Collection Survey production rate estimates are unrealistically high. If the survival and production rates used are correct, then low recruitment must account for the stable or slowly declining population indicated by survey data. Graphs are presented that display the effects of the parameter adjustments on four state/province data sets and on the continental black duck population data sets.
5. A sensitivity analysis was performed using the Eastern Lake Ontario(12) and New York(122) data sets. The age ratio and the adult male survival rate adjusted independently were found to have the greatest effect on population growth. However, the combined effects of adjustments in two or more survival parameters created substantially greater changes in population growth. Graphs are presented illustrating the results of the New York(122) sensitivity analysis.
6. To achieve population stability ($\lambda$ = 1.0) in the stochastic simulation model using the Brownie estimates

and production estimates derived from band recovery data and Duck Wing Collection Survey data, it was necessary to reduce each age–sex survival value by 4% to 14%, or to reduce the production rate, $\hat{\hat{P}}$, by 10% to 31% depending on the data set used.

# Part IV.

## Management Recommendations and Research Needs

# Management Recommendations

## *Regulations*

That restrictive regulations can reduce the size and rate of the waterfowl harvest has been demonstrated clearly (Martin et al. 1979; Rogers et al. 1979; Patterson 1979; Geis et al. 1969; Martinson et al. 1968). Although this study has not demonstrated that black duck harvest has affected survival (average harvest = 680,000; 1968–1979, or about one-fourth the estimated average population size of 2.8 million), the weight of evidence suggests that relief from intensive hunting pressure, especially on young birds, would benefit the black duck resource. Consideration must be given to the fact that where black ducks and mallards both occur in the harvest, a closed season on black ducks is unenforceable because of the "look-alike" appearance of black ducks and female mallards. In those regions where mallards are not important in the harvest, the absence of another principal game duck renders a closed season on black ducks difficult, but not impossible, to implement. Recognizing these realities, the following regulatory changes are suggested for the area described below as an initial strategy to decrease annual black duck harvest relative to black duck population size:

(1) delay season openings to allow the maturation of birds on the breeding grounds, and to permit the mixing of migrants into the local population;
(2) shorten season length to reduce total hunting pressure;
(3) close the black duck season earlier in the winter period, preferably by 1 January, to reduce losses and additional stress on those birds that have survived autumn hunting pressure and the initial stress of cold weather early in the wintering period.

The area to which these changes should apply includes Nova Scotia, New Brunswick, Prince Edward Island, Quebec, Ontario (zones 1 and 2; Cooch et al. 1974:10), the New England states, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, North Carolina, South Carolina, Michigan, and Ohio. These states and provinces have been selected on the basis of the estimated harvest rate they impose upon their own breeding populations, and/or the hunting pressure they exert on breeding populations that have already sustained high harvest rates prior to migration into a particular state.

It is assumed that appropriate field surveys and monitoring programs would be instituted in addition to the standard harvest surveys (banding to monitor recovery rates, Hunter Performance Surveys, and a program of increased law enforcement and public education about the need for regulatory change). A program designed to evaluate the effects of the regulatory changes over a 3- to five-year period would be necessary.

## *Banding*

Since 1965, the Atlantic Flyway states, the six eastern Canada provinces (Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland), the Canadian Wildlife Service, and the U.S. Fish and Wildlife Service have participated in a joint program to improve the quality of the black duck banding data (Eastern Canada Cooperative Banding Project Agreement).

Nearly 150,000 ducks have been banded in eastern Canada since 1965. Despite this effort black duck banding has been insufficient to estimate survival well in most parts of the breeding range. This problem has been noted by Boyd (1978), who despaired over the availability of sophisticated statistical models to estimate survival but which are so demanding of large quantities of input data, that for most waterfowl species the models are no more useful than are the previously used but now discredited methods. To accentuate this point, one conclusion from the mallard study (Anderson 1975), which used a data base of 3 million banded mallards, was that not enough banding had been done in some major breeding areas.

Since black ducks, because of their low densities, broad distribution, and more secretive habits are more difficult to capture in large numbers than the mallard, and because annual black duck banding quotas are attained only rarely, reconsideration should be given to the goals and annual objectives of the cooperative banding program.

Generally, an adequate number of adult birds has not been banded; the data base is particularly deficient in adult female bandings. Besides preventing the estimation of survival rates for many adequate samples of banded young birds (Brownie et al. 1978:112), the small banded adult samples introduce considerable variability into the relative recovery rate calculation which is used to estimate the age ratio in the population (production rate) from the age ratio in the kill. Thus the need to increase the banding of adult black ducks is of fundamental importance.

The current 5-year cooperative banding program should strive to (1) locate banding sites or general areas where adults are more concentrated than at present banding locations (a complicating factor is our ignorance of

the derivation of such concentrations) or (2) intensify banding efforts over a larger area within the present banding range.

If efforts to locate and band adult black ducks are unsuccessful, then redirection of the banding program should be considered. Future banding objectives likely would relate to monitoring recovery rates and marking black ducks from locations where they have not been banded previously to determine their distribution from the breeding grounds. Large scale banding efforts should be restricted to well designed research projects of local or regional importance. Consideration should be given to concentrating the banding program resources in specific areas (e.g., a province or major reference area) to extract, area by area and over a long time period, population information that has eluded management efforts over the past 20 years.

## Research Needs

Hochbaum (1944) identified the need for additional research on the postbreeding season habits and movements of waterfowl. Thirty-five years later, Fredrickson and Drobney (1979) cited our lack of knowledge about the postbreeding requirements of waterfowl. The authors suggested an approach to the design of postbreeding season studies. Several workers, Gilmer et al. (1977), Kirby and Cowardin (in press), and Kirby (1976), to name a few, have pioneered in this work with respect to mallards in north-central Minnesota. Similar studies related to the black duck within its primary breeding range are needed to improve our understanding of the nutritional and energy requirements imposed upon black ducks during the molt, in migration, and on the wintering grounds. Information developed from a study of black duck distribution from the breeding grounds (not presented here) indicates that an unknown but substantial degree of black duck movement occurs in late summer from any given breeding area into other preseason banding areas. These movements could, if they are general and extensive, confound our understanding of survival and recovery rate estimates for individual reference areas of banding, and thereby obscure our knowledge of the biological processes affecting black ducks in those areas. Better definition of late summer–early fall movements is needed.

Gilmer et al. (1977) estimated that 16% of the total annual mortality of mallards banded in north-central Minnesota occurred as winter mortality. However, Hagar (n.d.) estimated that under abnormally cold winter conditions, northern coastal wintering black ducks might suffer population losses up to 50% or more. Therefore, annual winter mortality may vary greatly and probably affects various breeding populations differently. An examination of the time and cause of all nonhunting waterfowl mortality by Stout and Cornwell (1976) revealed that seasonal losses peaked during winter and spring. Fretwell (1972) and Lack (1966) suggest that winter mortality may be an important factor in the survival of some bird populations and for certain species may be a limiting factor. Heitmeyer and Fredrickson (in press) have suggested that wintering grounds condition (e.g., water levels, food availability) is an important factor affecting waterfowl production. Certainly, the extent and condition of our coastal wintering habitats are an important determinant of winter survival (Boyd 1978; Chabreck 1979). Greater knowledge of the relationship of habitat conditions to winter survival, of winter mortality to annual survival, of winter stress and food availability to reproductive capability of northern migrants, and of the behavioral adaptations of black ducks to stressful conditions on the wintering grounds represent information deficits that require attention.

Of greater immediate importance, however, is the need to develop statistically appropriate field surveys to evaluate the effects of changes caused by natural phenomena or by various management efforts to improve black duck population status. Among these surveys are the Winter Survey, the Harvest Surveys, and productivity surveys. A winter survey that will yield a black duck population estimate with an associated confidence interval would be especially useful to determine changes in wintering black duck populations since a measure of the precision of theestimates would be available. The present Winter Survey lacks this capability.

The biases associated with the Waterfowl Parts Collection Survey (one of the Harvest Surveys) has been discussed earlier. Significant improvement is needed in the sampling procedure, or at a minimum, a statistical study of the biases that exist in the present system in needed.

Productivity surveys generally have been abandoned because of the time and manpower needed to conduct them. Also, difficulties are encountered in the survey process related to habitat types, time of day, movement of birds, and observation of broods, and in knowing the proportion of the broods present on an area that have been observed. However, productivity studies on local habitats may provide useful indices of production if survey methods can be standardized and designed with appropriate statistical considerations.

A fertile area of research exists in the study of the relationships and interactions of mallard and black duck populations within the exclusive range of the black duck. Mallard preseason bandings in many states and in one or two provinces commonly exceed black duck bandings. Comparative studies related to productivity, hybridization, survival, distribution from the breeding grounds, hunting pressure, and competition for nesting territories on the breeding grounds can be designed based on data provided, in part, from this study and the mallard study. Greater insight into how the mallard has succeeded so well within the black duck's traditional breeding range may provide information of management value as efforts continue to enhance the population status of the black duck.

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The banding files used in this study represent the work of scores of waterfowl banders. I thank all those individuals who have contributed to the banding program. They are formally recognized by name or agency in Appendix M of this dissertation.

To my wife Joan, who has encouraged my efforts over the years, and to Pam and Jonathan, who never quite understood what all the fuss was about, I offer my thanks and appreciation for their unfailing patience, companionship, and support.

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# Appendixes

# Appendix A. Black Duck Bandings by State or Province for the Period 1918 through 1978 (Preseason and Winter Bandings—Includes Normal, Wild Birds Only).

Table A1. *Black duck preseason bandings (July 1–September 30) by state or province for the period 1918–1978 (includes only normal, wild birds).*

| | Local | | Immature | | Total | Adult | | Total | Total |
|---|---|---|---|---|---|---|---|---|---|
| State/Province | Male | Female | Male | Female | young | Male | Female | adult | bandings |
| **Canada** | | | | | | | | | |
| AB | 1 | 1 | 3 | 0 | 5 | 34 | 2 | 36 | 41 |
| BC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MB | 0 | 1 | 46 | 17 | 64 | 521 | 55 | 576 | 640 |
| NB | 1,444 | 1,586 | 4,170 | 3,945 | 11,145 | 255 | 427 | 682 | 11,827 |
| NF | 9 | 10 | 669 | 762 | 1,450 | 508 | 232 | 740 | 2,190 |
| NS | 641 | 729 | 4,945 | 4,096 | 10,411 | 579 | 948 | 1,527 | 11,938 |
| ON | 130 | 117 | 14,441 | 10,106 | 24,794 | 4,984 | 3,016 | 8,000 | 32,794 |
| PE | 793 | 832 | 1,538 | 1,375 | 4,538 | 90 | 211 | 301 | 4,839 |
| QU | 2,133 | 2,102 | 7,000 | 5,773 | 17,008 | 3,598 | 2,275 | 5,873 | 22,881 |
| SK | 0 | 0 | 0 | 0 | 0 | 144 | 11 | 155 | 155 |
| **Totals** | 5,151 | 5,378 | 32,812 | 26,074 | 69,415 | 10,713 | 7,177 | 17,890 | 87,305 |
| **Atlantic Flyway** | | | | | | | | | |
| CT | 7 | 11 | 358 | 340 | 716 | 80 | 44 | 124 | 840 |
| DE | 42 | 42 | 1,109 | 960 | 2,153 | 355 | 446 | 801 | 2,954 |
| FL | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| GA | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ME | 1,063 | 1,031 | 10,792 | 9,694 | 22,580 | 1,011 | 1,500 | 2,511 | 25,091 |
| MD | 264 | 249 | 2,772 | 1,693 | 4,978 | 1,037 | 751 | 1,788 | 6,766 |
| MA | 242 | 242 | 4,842 | 4,194 | 9,520 | 1,535 | 2,015 | 3,550 | 13,070 |
| NH | 2 | 5 | 619 | 570 | 1,196 | 58 | 113 | 171 | 1,367 |
| NJ | 235 | 212 | 469 | 335 | 1,251 | 119 | 74 | 193 | 1,444 |
| NY | 127 | 139 | 11,455 | 9,293 | 21,014 | 4,034 | 3,592 | 7,626 | 28,640 |
| NC | 24 | 29 | 594 | 663 | 1,310 | 31 | 92 | 123 | 1,433 |
| PA | 1 | 1 | 138 | 106 | 246 | 225 | 100 | 325 | 571 |
| RI | 0 | 3 | 322 | 266 | 591 | 33 | 36 | 69 | 660 |
| SC | 0 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 2 |
| VT | 55 | 61 | 5,507 | 4,176 | 9,799 | 769 | 677 | 1,446 | 11,245 |
| VA | 34 | 47 | 7 | 4 | 92 | 6 | 7 | 13 | 105 |
| WV | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 4 | 4 |
| **Totals** | 2,096 | 2,072 | 38,984 | 32,296 | 75,448 | 9,295 | 9,449 | 18,744 | 94,192 |
| **Miss. Flyway** | | | | | | | | | |
| AL | 0 | 0 | 1 | 1 | 2 | 0 | 0 | 0 | 2 |
| AK | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| IL | 0 | 0 | 602 | 327 | 929 | 185 | 37 | 222 | 1,151 |
| IN | 6 | 4 | 191 | 149 | 350 | 103 | 72 | 175 | 525 |
| IA | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| KY | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 3 | 3 |
| LA | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MI | 76 | 112 | 6,004 | 4,091 | 10,283 | 2,608 | 1,631 | 4,239 | 14,522 |
| MN | 2 | 6 | 459 | 226 | 693 | 885 | 207 | 1,092 | 1,785 |

Table A1. *Continued.*

| State/Province | Local | | Immature | | Total | Adult | | Total | Total |
|---|---|---|---|---|---|---|---|---|---|
| | Male | Female | Male | Female | young | Male | Female | adult | bandings |
| MS | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MO | 0 | 0 | 2 | 0 | 2 | 1 | 0 | 1 | 3 |
| OH | 17 | 8 | 758 | 510 | 1,293 | 438 | 267 | 705 | 1,998 |
| TN | 0 | 0 | 2 | 1 | 3 | 4 | 0 | 4 | 7 |
| WI | 13 | 8 | 1,022 | 763 | 1,806 | 665 | 671 | 1,336 | 3,142 |
| **Totals** | 114 | 138 | 9,041 | 6,068 | 15,361 | 4,891 | 2,886 | 7,777 | 23,138 |
| **Grand Totals** | 7,361 | 7,588 | 80,837 | 64,438 | 160,224 | 24,899 | 19,512 | 44,411 | 204,635 |

Table A2. *Black duck winter bandings (1 January–28 February) by state or province for the period 1918–1978 (includes only normal, wild birds).*

| State/Province | Adult Male | Adult Female | Total adult bandings |
|---|---|---|---|
| **Canada** | | | |
| AB | 0 | 0 | 0 |
| BC | 0 | 0 | 0 |
| MB | 0 | 0 | 0 |
| NB | 0 | 0 | 0 |
| NF | 0 | 0 | 0 |
| NS | 2,406 | 1,260 | 3,666 |
| ON | 334 | 175 | 509 |
| PE | 1,544 | 542 | 2,086 |
| QU | 0 | 0 | 0 |
| SK | 0 | 0 | 0 |
| **Totals** | 4,284 | 1,977 | 6,261 |
| **Atlantic Flyway** | | | |
| CT | 1,171 | 546 | 1,717 |
| DE | 4,002 | 2,608 | 6,610 |
| FL | 24 | 26 | 50 |
| GA | 73 | 84 | 157 |
| ME | 4,040 | 1,886 | 5,926 |
| MD | 6,137 | 4,260 | 10,397 |
| MA | 16,231 | 9,430 | 25,661 |
| NH | 392 | 135 | 527 |
| NJ | 14,110 | 9,699 | 23,809 |
| NY | 12,865 | 7,583 | 20,448 |
| NC | 4,937 | 3,825 | 8,762 |
| PA | 1,452 | 924 | 2,376 |
| RI | 894 | 483 | 1,377 |
| SC | 955 | 939 | 1,894 |
| VT | 27 | 14 | 41 |
| VA | 3,985 | 2,937 | 6,922 |
| WV | 237 | 141 | 378 |
| **Totals** | 71,532 | 45,520 | 117,052 |
| **Miss. Flyway** | | | |
| AL | 601 | 583 | 1,184 |
| AR | 508 | 345 | 853 |
| IL | 3,480 | 2,540 | 6,020 |
| IN | 2,627 | 1,512 | 4,139 |
| IA | 10 | 2 | 12 |
| KY | 1,249 | 806 | 2,055 |
| LA | 23 | 27 | 50 |
| MI | 5,526 | 2,266 | 7,792 |
| MN | 53 | 26 | 79 |
| MS | 247 | 227 | 474 |
| MO | 153 | 94 | 247 |
| OH | 2,287 | 1,240 | 3,527 |
| TN | 12,706 | 9,311 | 22,017 |
| WI | 102 | 39 | 141 |
| **Totals** | 29,572 | 19,018 | 48,590 |
| **Grand Totals** | 105,388 | 66,515 | 171,903 |

# Appendix B. Estimates of Survival and Recovery Rates for Black Ducks Banded as Adults and Young in the Preseason Period by State/Province of Banding.

Estimates of recovery and survival rates and their standard errors were made using the models for preseason banded adults and young (Program Brownie) as described in Brownie et al. (1978). The "best fit" model is presented. Mean values and their standard errors also are presented. The number banded by year and in total, and the total recoveries used in the analysis, are given as a guide to the quantity of data in each area. Test statistics for the goodness-of-fit of the models are also given. Figure 2 in the text shows the location of each banding reference area.

Table B1. *Estimates of survival and recovery rates for black ducks banded as adults in Maine (044).*

| Males | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1962 | 122 | 64.88* | 2.58* | 5.51 | 0.79* |
| 1963 | 107 | | | | |
| 1964 | 107 | | | | |
| **Mean** | 112.00 | 64.88 | 2.58 | 5.51 | 0.79 |
| Total banded = 336 | | Total recoveries = 51 | | | $\chi^2$ = 11.56, 10 df |
| | | Model HO1 | | | |

| Females | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1961 | 80 | 50.68* | 3.09* | 4.96 | 2.42 |
| 1962 | 203 | | | 7.48 | 1.40 |
| 1963 | 175 | | | 6.56 | 1.07 |
| 1964 | 103 | | | 5.76 | 1.00 |
| 1965 | 83 | | | 4.92 | 0.97 |
| 1966 | 73 | | | 4.91 | 1.01 |
| **Mean** | 119.83 | 50.68 | 3.09 | 5.76 | 0.70 |
| Total banded = 719 | | Total recoveries = 87 | | | $\chi^2$ = 40.09, 35 df |
| | | Model HO2 | | | |

* Average value.

Table B2. *Estimates of survival and recovery rates for black ducks banded as adults in Massachusetts (047).*

| Males | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1968 | 106 | 74.53* | 7.38* | 4.68 | 2.05 |
| 1969 | 107 | | | 4.40 | 1.18 |
| 1970 | 122 | | | 4.49 | 1.05 |
| 1971 | 100 | | | 2.47 | 0.70 |
| **Mean** | 108.75 | 74.53 | 7.38 | 4.01 | 0.73 |
| Total banded = 435 | | Total recoveries = 49 | | | $\chi^2$ = 13.95, 21 df |
| | | Model HO2 | | | |

| Females | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1968 | 124 | 34.64 | 18.44 | 7.26 | 2.33 |
| 1969 | 246 | 47.26 | 16.25 | 4.72 | 1.21 |
| 1970 | 234 | 67.56 | 33.65 | 5.70 | 1.35 |
| 1971 | 165 | | | 2.34 | 0.99 |
| **Mean** | 192.25 | 49.82 | 12.06 | 5.00 | 0.78 |
| Total banded = 769 | | Total recoveries = 61 | | | $\chi^2$ = 9.93, 7 df |
| | | Model H1 | | | |

* Average value.

Table B3. *Estimates of survival and recovery rates for black ducks banded as adults in Michigan (049).*

| Males | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1967 | 114 | 63.35* | 2.38* | 6.75* | 0.65* |
| 1968 | 139 | | | | |
| 1969 | 64 | | | | |
| 1970 | 140 | | | | |
| 1971 | 43 | | | | |
| 1972 | 156 | | | | |
| 1973 | 88 | | | | |
| **Mean** | 106.28 | 63.35 | 2.38 | 6.75 | 0.65 |
| Total banded = 744 | | Total recoveries = 127 | | | $\chi^2$ = 11.80, 16 df |
| | | Model HO1 | | | |

* Average value.

Table B4. *Estimates of survival and recovery rates for black ducks banded as adults in New York (061).*

| Males | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1950 | 245 | 53.59* | 4.70* | 5.69 | 1.48 |
| 1951 | 124 | | | 6.96 | 1.45 |
| 1952 | 185 | | | 5.86 | 1.16 |
| 1953 | 124 | | | 7.14 | 1.34 |
| **Mean** | 169.50 | 53.59 | 4.70 | 6.41 | 0.77 |
| Total banded = 678 | | Total recoveries = 95 | | | $\chi^2$ = 31.14, 25 df |
| | | Model HO2 | | | |

| Males | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1960 | 242 | 59.56* | 1.07* | 7.00* | 0.36* |
| 1961 | 328 | | | | |
| 1962 | 247 | | | | |
| 1963 | 196 | | | | |
| 1964 | 180 | | | | |
| 1965 | 345 | | | | |
| 1966 | 127 | | | | |
| 1967 | 151 | | | | |
| 1968 | 74 | | | | |
| 1969 | 254 | | | | |
| 1970 | 48 | | | | |
| 1971 | 123 | | | | |
| 1972 | 117 | | | | |
| **Mean** | 187.08 | 59.56 | 1.07 | 7.00 | 0.36 |
| Total banded = 2,432 | | Total recoveries = 391 | | | $\chi^2$ = 298.87, 116 df |
| | | Model HO1 | | | |

* Average value.

Table B5. *Estimates of survival and recovery rates for black ducks banded as adults in New York (061).*

Females

| Year | Number banded | Survival | S.E. | Recovery | S.E. |
|---|---|---|---|---|---|
| 1950 | 150 | 31.52 | 13.45 | | |
| 1951 | 89 | 70.98 | 27.99 | 19.01 | 8.64 |
| 1952 | 178 | 63.81 | 30.40 | 7.49 | 2.89 |
| 1953 | 97 | 33.77 | 19.12 | 6.01 | 2.77 |
| 1954 | 68 | | | 7.11 | 3.29 |
| **Mean** | 116.40 | 50.02 | 6.65 | 9.91 | 2.52 |

Total banded = 582 Total recoveries = 75 $\chi^2$ = 12.09, 15 df

Model H2

Females

| Year | Number banded | Survival | S.E. | Recovery | S.E. |
|---|---|---|---|---|---|
| 1960 | 206 | 55.74 | 23.67 | | |
| 1961 | 216 | 50.69 | 14.43 | 2.11 | 1.08 |
| 1962 | 310 | 55.58 | 16.44 | 6.80 | 2.13 |
| 1963 | 292 | 97.03 | 36.84 | 4.96 | 1.47 |
| 1964 | 251 | 48.52 | 22.25 | 3.42 | 1.25 |
| 1965 | 211 | 22.73 | 9.57 | 3.16 | 1.22 |
| 1966 | 196 | | | 9.59 | 3.09 |
| **Mean** | 240.29 | 53.38 | 5.01 | 5.01 | 0.75 |

Total banded = 1,682 Total recoveries = 248 $\chi^2$ = 34.24, 35 df

Model H2

Table B6. *Estimates of survival and recovery rates for black ducks banded as adults in Ontario (068).*

| Males | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1964 | 452 | 61.49* | 1.13* | 4.63 | 0.99 |
| 1965 | 365 | | | 8.27 | 0.98 |
| 1966 | 278 | | | 7.93 | 0.86 |
| 1967 | 389 | | | 7.56 | 0.74 |
| 1968 | 439 | | | 5.44 | 0.57 |
| 1969 | 263 | | | 5.55 | 0.58 |
| 1970 | 305 | | | 6.88 | 0.67 |
| 1971 | 478 | | | 6.73 | 0.60 |
| 1972 | 348 | | | 6.13 | 0.56 |
| 1973 | 195 | | | 5.44 | 0.57 |
| 1974 | 126 | | | 4.93 | 0.59 |
| 1975 | 96 | | | 5.04 | 0.68 |
| 1976 | 117 | | | 6.48 | 0.86 |
| 1977 | 155 | | | 4.28 | 0.65 |
| **Mean** | 286.14 | 61.49 | 1.13 | 6.09 | 0.28 |

Total banded = 4,006 Total recoveries = 606 $\chi^2$ = 131.97, 116 df

Model HO2

| Females | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1964 | 202 | 31.80 | 12.14 | 7.92 | 1.90 |
| 1965 | 280 | 37.71 | 9.82 | 6.28 | 1.29 |
| 1966 | 237 | 39.49 | 9.76 | 9.11 | 1.59 |
| 1967 | 259 | 54.04 | 12.96 | 7.41 | 1.29 |
| 1968 | 225 | 60.30 | 17.13 | 6.56 | 1.23 |
| 1969 | 166 | 47.92 | 13.82 | 5.25 | 1.24 |
| 1970 | 231 | 70.75 | 18.31 | 4.78 | 0.99 |
| 1971 | 263 | 66.69 | 21.79 | 4.54 | 0.91 |
| 1972 | 152 | | | 4.07 | 1.14 |
| **Mean** | 223.89 | 51.09 | 3.11 | 6.21 | 0.44 |

Total banded = 2,015 Total recoveries = 253 $\chi^2$ = 57.65, 45 df

Model H1

Table B7. *Estimates of survival and recovery rates for black ducks banded as adults in Quebec (076).*

Males

| Year | Number banded | Survival | S.E. | Recovery | S.E. |
|---|---|---|---|---|---|
| 1963 | 116 | 64.81* | 1.56* | 6.78 | 2.33 |
| 1964 | 148 | | | 5.68 | 1.38 |
| 1965 | 99 | | | 5.34 | 1.18 |
| 1966 | 109 | | | 4.96 | 1.02 |
| 1967 | 96 | | | 6.47 | 1.19 |
| 1968 | 256 | | | 4.16 | 0.79 |
| 1969 | 282 | | | 6.55 | 0.84 |
| 1970 | 247 | | | 5.95 | 0.79 |
| 1971 | 234 | | | 5.50 | 0.74 |
| 1972 | 299 | | | 5.09 | 0.66 |
| 1973 | 166 | | | 4.42 | 0.71 |
| 1974 | 230 | | | 5.52 | 0.72 |
| 1975 | 212 | | | 6.55 | 0.81 |
| **Mean** | 191.85 | 61.81 | 1.56 | 5.69 | 0.36 |

Total banded = 2,494 | Total recoveries = 366 | $\chi^2$ = 108.78, 94 df

Model HO2

Females

| Year | Number banded | Survival | S.E. | Recovery | S.E. |
|---|---|---|---|---|---|
| 1968 | 238 | 60.33* | 4.85* | 7.85 | 1.74 |
| 1969 | 212 | | | 4.68 | 0.94 |
| 1970 | 177 | | | 4.78 | 0.94 |
| 1971 | 191 | | | 4.74 | 0.95 |
| **Mean** | 204.50 | 60.33 | 4.85 | 5.52 | 0.65 |

Total banded = 818 | Total recoveries = 102 | $\chi^2$ = 27.89, 24 df

Model HO2

* Average value.

Table B8. *Estimates of survival and recovery rates for black ducks banded as young in Maine (044).*

| Year | Number banded | Survival | S.E. | Recovery | S.E. |
|---|---|---|---|---|---|
| | | Males | | | |
| 1962 | 882 | 45.26* | 6.70* | 9.17* | 0.57* |
| 1963 | 995 | | | | |
| 1964 | 730 | | | | |
| **Mean** | 869.00 | 45.26 | 6.70 | 9.17 | 0.57 |
| Total banded = 2,607 | | Total recoveries = 415 | | | $\chi^2$ = 11.56, 10 df |
| | | Model HO1 | | | |

| Year | Number banded | Survival | S.E. | Recovery | S.E. |
|---|---|---|---|---|---|
| | | Females | | | |
| 1961 | 314 | 45.24* | 6.07* | 11.32 | 1.78 |
| 1962 | 836 | | | 11.48 | 1.10 |
| 1963 | 925 | | | 9.84 | 0.98 |
| 1964 | 647 | | | 13.41 | 1.34 |
| 1965 | 612 | | | 13.23 | 1.37 |
| 1966 | 740 | | | 11.58 | 1.17 |
| **Mean** | 679.00 | 45.24 | 6.07 | 11.81 | 0.54 |
| Total banded = 4,074 | | Total recoveries = 689 | | | $\chi^2$ = 40.09, 35 df |
| | | Model HO2 | | | |

* Average value.

Table B9. *Estimates of survival and recovery rates for black ducks banded as young in Massachusetts (047).*

| Year | Number banded | Survival | S.E. | Recovery | S.E. |
|---|---|---|---|---|---|
| | | Males | | | |
| 1968 | 307 | 58.16* | 11.36* | 9.22 | 1.65 |
| 1969 | 354 | | | 10.36 | 1.62 |
| 1970 | 382 | | | 10.47 | 1.56 |
| 1971 | 362 | | | 8.28 | 1.45 |
| **Mean** | 351.25 | 58.16 | 11.36 | 9.58 | 0.79 |
| Total banded = 1,405 | | Total recoveries = 213 | | | $\chi^2$ = 13.95, 21 df |
| | | Model HO2 | | | |

| Year | Number banded | Survival | S.E. | Recovery | S.E. |
|---|---|---|---|---|---|
| | | Females | | | |
| 1968 | 236 | 45.50 | 16.85 | 11.02 | 2.04 |
| 1969 | 319 | 38.59 | 14.10 | 7.52 | 1.48 |
| 1970 | 354 | 40.19 | 22.89 | 8.76 | 1.50 |
| 1971 | 314 | | | 6.37 | 1.38 |
| **Mean** | 305.75 | 41.43 | 10.58 | 8.42 | 0.81 |
| Total banded = 1,223 | | Total recoveries = 141 | | | $\chi^2$ = 9.93, 7 df |
| | | Model H1 | | | |

* Average value.

Table B10. *Estimates of survival and recovery rates for black ducks banded as young in Michigan (049).*

| | | Males | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1967 | 382 | 43.03* | 5.25* | 7.06* | 0.68* |
| 1968 | 461 | | | | |
| 1969 | 179 | | | | |
| 1970 | 85 | | | | |
| 1971 | 49 | | | | |
| 1972 | 138 | | | | |
| 1973 | 109 | | | | |
| **Mean** | 200.43 | 43.03 | 5.25 | 7.06 | 0.68 |
| Total banded = 1,403 | | Total recoveries = 206 | | | $\chi^2$ = 11.80, 16 df |
| | | Model HO1 | | | |

* Average value.

Table B11. *Estimates of survival and recovery rates for black ducks banded as young in New York (061).*

| | | Males | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1950 | 233 | 43.31* | 7.11* | 5.64 | 1.51 |
| 1951 | 342 | | | 13.92 | 1.87 |
| 1952 | 604 | | | 10.59 | 1.25 |
| 1953 | 514 | | | 12.42 | 1.45 |
| **Mean** | 423.25 | 43.31 | 7.11 | 10.65 | 0.77 |
| Total banded = 1,693 | | Total recoveries = 296 | | | $\chi^2$ = 31.14, 25 df |
| | | Model HO2 | | | |

| | | Males | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1960 | 509 | 44.84* | 2.70* | 12.81* | 0.38* |
| 1961 | 710 | | | | |
| 1962 | 565 | | | | |
| 1963 | 760 | | | | |
| 1964 | 743 | | | | |
| 1965 | 813 | | | | |
| 1966 | 820 | | | | |
| 1967 | 889 | | | | |
| 1968 | 586 | | | | |
| 1969 | 565 | | | | |
| 1970 | 301 | | | | |
| 1971 | 227 | | | | |
| 1972 | 168 | | | | |
| **Mean** | 588.92 | 44.84 | 2.70 | 12.81 | 0.38 |
| Total banded = 7,656 | | Total recoveries = 1,568 | | | $\chi^2$ = 107.43, 90 df |
| | | Model HO1 | | | |

* Average value.

Table B12. *Estimates of survival and recovery rates for black ducks banded as young in New York (061).*

| Females | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1950 | 288 | 17.44 | 7.43 | 8.33 | 1.63 |
| 1951 | 327 | 35.13 | 12.31 | 8.26 | 1.52 |
| 1952 | 524 | 42.00 | 18.80 | 9.54 | 1.28 |
| 1953 | 472 | 26.60 | 12.07 | 13.56 | 1.58 |
| 1954 | 400 | | | 10.75 | 1.55 |
| **Mean** | 402.75 | 30.29 | 6.64 | 10.09 | 0.68 |
| Total banded = 2,011 | | Total recoveries = 309 | | | $\chi^2$ = 12.09, 15 df |
| | | Model H2 | | | |

| Females | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1960 | 478 | 40.83 | 15.39 | 13.39 | 1.56 |
| 1961 | 594 | 40.97 | 11.56 | 10.94 | 1.28 |
| 1962 | 477 | 45.55 | 12.85 | 7.97 | 1.24 |
| 1963 | 563 | 63.46 | 23.47 | 11.72 | 1.36 |
| 1964 | 599 | 54.90 | 21.23 | 11.35 | 1.30 |
| 1965 | 619 | 20.66 | 6.88 | 10.02 | 1.21 |
| 1966 | 539 | | | 15.58 | 1.56 |
| **Mean** | 552.71 | 44.39 | 6.63 | 11.57 | 0.52 |
| Total banded = 3,869 | | Total recoveries = 640 | | | $\chi^2$ = 32.24, 35 df |
| | | Model H2 | | | |

Table B13. *Estimates of survival and recovery rates for black ducks banded as young in Ontario (068).*

| Males | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1964 | 378 | 47.34* | 2.60 | 23.47 | 1.73 |
| 1965 | 641 | | | 15.33 | 1.41 |
| 1966 | 770 | | | 11.75 | 1.16 |
| 1967 | 962 | | | 9.83 | 0.96 |
| 1968 | 972 | | | 10.18 | 0.97 |
| 1969 | 701 | | | 11.91 | 1.22 |
| 1970 | 1,402 | | | 10.20 | 0.81 |
| 1971 | 1,388 | | | 11.00 | 0.84 |
| 1972 | 797 | | | 11.16 | 1.11 |
| 1973 | 714 | | | 12.05 | 1.21 |
| 1974 | 342 | | | 10.42 | 1.65 |
| 1975 | 334 | | | 8.32 | 1.51 |
| 1976 | 690 | | | 10.43 | 1.16 |
| 1977 | 667 | | | 8.40 | 1.07 |
| **Mean** | 768.43 | 47.34 | 2.60 | 11.03 | 0.33 |
| Total banded = 10,758 | | Total recoveries = 1,846 | | | $\chi^2$ = 131.97, 116 df |
| | | Model HO2 | | | |

| Females | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1964 | 375 | 34.26 | 10.03 | 9.33 | 1.50 |
| 1965 | 508 | 39.25 | 9.11 | 10.04 | 1.33 |
| 1966 | 696 | 42.03 | 8.67 | 12.36 | 1.25 |
| 1967 | 693 | 52.99 | 11.32 | 10.82 | 1.18 |
| 1968 | 752 | 42.19 | 11.29 | 10.11 | 1.10 |
| 1969 | 515 | 37.54 | 9.80 | 9.71 | 1.30 |
| 1970 | 1,014 | 52.07 | 11.43 | 11.93 | 1.02 |
| 1971 | 950 | 43.71 | 13.52 | 10.84 | 1.01 |
| 1972 | 521 | | | 7.10 | 1.13 |
| **Mean** | 669.33 | 43.01 | 3.80 | 10.25 | 0.40 |
| Total banded = 6,024 | | Total recoveries = 963 | | | $\chi^2$ = 57.65, 45 df |
| | | Model H1 | | | |

* Average value.

Table B14. *Estimates of survival and recovery rates for black ducks banded as young in Quebec (076).*

| Males | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1963 | 157 | 38.77* | 2.91* | 7.67 | 2.12 |
| 1964 | 238 | | | 9.08 | 1.86 |
| 1965 | 329 | | | 11.83 | 1.77 |
| 1966 | 169 | | | 9.07 | 2.20 |
| 1967 | 300 | | | 13.70 | 1.98 |
| 1968 | 655 | | | 12.43 | 1.28 |
| 1969 | 389 | | | 16.40 | 1.87 |
| 1970 | 492 | | | 12.51 | 1.49 |
| 1971 | 786 | | | 10.96 | 1.11 |
| 1972 | 646 | | | 8.96 | 1.12 |
| 1973 | 587 | | | 8.13 | 1.13 |
| 1974 | 431 | | | 13.95 | 1.66 |
| 1975 | 518 | | | 9.79 | 1.30 |
| **Mean** | 438.23 | 38.77 | 2.91 | 11.11 | 0.46 |

Total banded = 5,697 | Total recoveries 943 | $\chi^2$ = 108.78, 94 df

Model HO2

| Females | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1968 | 576 | 41.45* | 6.56* | 10.46 | 1.27 |
| 1969 | 381 | | | 14.32 | 1.79 |
| 1970 | 367 | | | 11.62 | 1.67 |
| 1971 | 678 | | | 8.81 | 1.09 |
| **Mean** | 500.50 | 41.45 | 6.56 | 11.30 | 0.74 |

Total banded = 2,002 | Total recoveries = 310 | $\chi^2$ = 27.89, 24 df

Model HO2

* Average value.

# Appendix C. Estimates of Survival and Recovery Rates for Black Ducks Banded as Adults and Young in the Preseason Period by Major Reference Area of Banding.

Estimates of recovery and survival rates and their standard errors were made using the models for preseason banded adults and young (Program Brownie) as described in Brownie et al. (1978). The "best fit" model is presented. Mean values and their standard errors also are presented. The number banded by year and in total, and the total recoveries used in the analysis, are given as a guide to the quantity of data in each area. Test statistics for the goodness-of-fit of the models are given. Figure 2 in the text shows the location of each banding reference area.

Table C1. *Estimates of survival and recovery rates for black ducks banded as adults in the Maritimes (010).*

| | | Females | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1970 | 104 | 43.84 | 3.99 | 6.68 | 2.45 |
| 1971 | 128 | | | 4.84 | 1.14 |
| 1972 | 80 | | | 7.80 | 1.52 |
| 1973 | 101 | | | 5.96 | 1.28 |
| 1974 | 113 | | | 6.35 | 1.27 |
| **Mean** | 105.20 | 43.84 | 3.99 | 6.33 | 0.88 |
| Total banded = 526 | | Total recoveries = 57 | | | $\chi^2$ = 23.41, 19 df |
| | | Model HO2 | | | |

* Average value.

Table C2. *Estimates of survival and recovery rates for black ducks banded as adults in Labrador & Eastern Quebec (020).*

| | | Males | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1962 | 124 | 69.39* | 4.93* | 5.15* | 0.88* |
| 1963 | 95 | | | | |
| 1964 | 137 | | | | |
| **Mean** | 118.67 | 69.39 | 4.93 | 5.15 | 0.88 |
| Total banded = 356 | | Total recoveries = 55 | | | |
| | | Model HO1 | | | |

* Average value.

Table C3. *Estimates of survival and recovery rates for black ducks banded as adults in Southern Quebec (040).*

| Males | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1968 | 210 | 66.02* | 2.32* | 5.70 | 1.49 |
| 1969 | 220 | | | 8.25 | 1.21 |
| 1970 | 167 | | | 6.82 | 1.05 |
| 1971 | 163 | | | 5.90 | 0.94 |
| 1972 | 137 | | | 5.23 | 0.85 |
| 1973 | 91 | | | 6.13 | 0.96 |
| 1974 | 151 | | | 5.96 | 0.94 |
| 1975 | 165 | | | 7.42 | 1.08 |
| **Mean** | 163.00 | 66.02 | 2.32 | 6.43 | 0.50 |
| Total banded = 1,304 | | Total recoveries = 215 | | | $\chi^2$ = 65.53, 55 df |
| | | Model HO2 | | | |

| Females | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1968 | 199 | 60.04* | 5.10* | 8.90* | 2.01 |
| 1969 | 174 | | | 5.30 | 1.10 |
| 1970 | 131 | | | 4.80 | 1.05 |
| 1971 | 158 | | | 4.51 | 1.01 |
| **Mean** | 165.50 | 60.04 | 5.10 | 5.88 | 0.73 |
| Total banded = 662 | | Total recoveries = 89 | | | $\chi^2$ = 22.08, 22 df |
| | | Model HO2 | | | |

* Average value.

Table C4. *Estimates of survival and recovery rates for black ducks banded as adults in Eastern Lake Ontario (120).*

| Males | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1950 | 184 | 58.32 | 21.32 | 6.52 | 1.82 |
| 1951 | 92 | 37.59 | 14.67 | 7.64 | 2.29 |
| 1952 | 138 | 30.23 | 9.90 | 6.88 | 1.84 |
| 1953 | 100 | | | 8.43 | 2.10 |
| **Mean** | 122.50 | 42.05 | 6.21 | 7.37 | 1.01 |

Total banded = 514 Total recoveries = 187

Model H1

| Males | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1960 | 238 | 58.07* | 1.24 | 6.77 | 1.63 |
| 1961 | 286 | | | 6.38 | 0.98 |
| 1962 | 225 | | | 6.16 | 0.86 |
| 1963 | 198 | | | 8.61 | 1.02 |
| 1964 | 188 | | | 5.70 | 0.78 |
| 1965 | 331 | | | 7.01 | 0.79 |
| 1966 | 146 | | | 7.87 | 0.89 |
| 1967 | 185 | | | 6.60 | 0.80 |
| 1968 | 93 | | | 7.03 | 0.86 |
| 1969 | 233 | | | 7.65 | 0.87 |
| 1970 | 145 | | | 7.14 | 0.88 |
| 1971 | 283 | | | 6.10 | 0.73 |
| 1972 | 180 | | | 7.22 | 0.82 |
| **Mean** | 210.08 | 58.07 | 1.24 | 6.94 | 0.36 |

Total banded = 2,731 Total recoveries = 406

Model HO2

* Average value.

Table C5. *Estimates of survival and recovery rates for black ducks banded as adults in Eastern Lake Ontario (120).*

| Year | Number banded | Survival | S.E. | Recovery | S.E. |
|---|---|---|---|---|---|
| | | Females | | | |
| 1960 | 198 | 65.16 | 28.70 | | |
| 1961 | 208 | 36.43 | 13.80 | 1.85 | 0.98 |
| 1962 | 306 | 55.45 | 17.09 | 6.74 | 2.20 |
| 1963 | 283 | 89.47 | 33.55 | 5.00 | 1.57 |
| 1964 | 271 | 39.82 | 17.41 | 3.57 | 1.29 |
| 1965 | 195 | 35.99 | 14.54 | 4.19 | 1.57 |
| 1966 | 255 | 62.68 | 23.48 | 6.84 | 2.24 |
| 1967 | 199 | 36.54 | 17.14 | 3.84 | 1.36 |
| 1968 | 92 | 62.24 | 32.65 | 6.99 | 2.92 |
| 1969 | 120 | 62.83 | 33.17 | 4.95 | 2.08 |
| 1970 | 142 | 26.46 | 12.70 | 3.25 | 1.41 |
| 1971 | 132 | | | 8.88 | 3.14 |
| **Mean** | 200.08 | 52.10 | 3.52 | 5.10 | 0.60 |

Total banded = 2,401 Total recoveries = 356

Model H2

Table C6. *Estimates of survival and recovery rates for black ducks banded as adults in Western Lake Ontario (130).*

Males

| Year | Number banded | Survival | S.E. | Recovery | S.E. |
|---|---|---|---|---|---|
| 1965 | 199 | 62.27* | 2.03* | 7.45 | 1.85 |
| 1966 | 121 | | | 6.42 | 1.11 |
| 1967 | 167 | | | 6.88 | 0.99 |
| 1968 | 111 | | | 6.23 | 0.91 |
| 1969 | 170 | | | 6.23 | 0.87 |
| 1970 | 142 | | | 6.68 | 0.94 |
| 1971 | 193 | | | 7.09 | 0.94 |
| 1972 | 182 | | | 6.18 | 0.84 |
| **Mean** | 160.63 | 62.27 | 2.03 | 6.64 | 0.50 |
| Total banded = 1,285 | | Total recoveries = 207 | | | $\chi^2$ = 84.68, 65 df |
| | | Model HO2 | | | |

Females

| Year | Number banded | Survival | S.E. | Recovery | S.E. |
|---|---|---|---|---|---|
| 1965 | 185 | 48.27* | 4.90* | 5.58 | 1.72 |
| 1966 | 106 | | | 5.62 | 1.24 |
| 1967 | 103 | | | 6.04 | 1.31 |
| 1968 | 99 | | | 6.05 | 1.34 |
| **Mean** | 123.25 | 48.27 | 4.90 | 5.83 | 1.40 |
| Total banded = 493 | | Total recoveries = 54 | | | $\chi^2$ = 24.46, 17 df |
| | | Model HO2 | | | |

* Average value.

Table C7. *Estimates of survival and recovery rates for black ducks banded as adults in Upper Great Lakes (150).*

| Males | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1964 | 300 | 63.88* | 3.30* | 5.35 | 1.30 |
| 1965 | 134 | | | 6.05 | 1.19 |
| 1966 | 169 | | | 8.14 | 1.29 |
| 1967 | 193 | | | 7.71 | 1.15 |
| 1968 | 276 | | | 5.09 | 0.81 |
| **Mean** | 214.40 | 63.88 | 3.30 | 6.47 | 0.58 |
| Total banded = 1,072 | | Total recoveries = 186 | | | $\chi^2$ = 37.07, 37 df |
| | | Model HO2 | | | |

| Females** | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1964 | 290 | 49.88* | 3.47* | 6.41* | 0.84* |
| 1965 | 248 | | | | |
| 1966 | 347 | | | | |
| 1967 | 346 | | | | |
| 1968 | 469 | | | | |
| **Mean** | 339.60 | 49.88 | | 6.41 | 0.84 |
| Total banded = 1,698 | | Total recoveries = 251 | | | $\chi^2$ = 18.30, 10 df |
| MLS = 1.33 | | Model 1 | | | |

* Average value.
** Adult and young banding data are pooled. The hypothesis that annual survival and recovery rates are independent of age (Model Ho) could not be rejected: $\chi^2$ = 4.763 (df = 10).

Table C8. *Estimates of survival and recovery rates for black ducks banded as adults in Western Lake Erie (160).*

| Males* | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1968 | 349 | 57.46* | 3.22** | 8.78 | 1.51 |
| 1969 | 191 | | | 5.59 | 1.18 |
| 1970 | 233 | | | 9.70 | 1.47 |
| 1971 | 174 | | | 5.66 | 1.17 |
| 1972 | 294 | | | 7.56 | 1.21 |
| 1973 | 274 | | | 8.02 | 1.21 |
| **Mean** | 252.50 | 57.46 | 3.22 | 7.55 | 0.58 |
| Total banded = 1,515 | | Total recoveries = 258 | | | $\chi^2$ = 33.26, 22 df |
| MLS = 1.80 | | Model 2 | | | |

* Adult and young banding data are pooled. The hypothesis that annual survival and recovery rates are independent of age (Model Ho) could not be rejected: $\chi^2$ = 9.85 (df = 8).
** Average value.

Table C9. *Estimates of survival and recovery rates for black ducks banded as young in the Maritimes (010).*

| | | Females | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1970 | 713 | 36.25* | 5.87* | 10.54 | 1.15 |
| 1971 | 817 | | | 12.28 | 1.15 |
| 1972 | 610 | | | 13.04 | 1.36 |
| 1973 | 915 | | | 12.58 | 1.09 |
| 1974 | 608 | | | 10.34 | 1.23 |
| **Mean** | 732.60 | 36.25 | 5.87 | 11.76 | 0.54 |
| Total banded = 3,663 | | Total recoveries = 574 | | | $\chi^2$ = 23.41, 19 df |
| | | Model HO2 | | | |

* Average value.

Table C10. *Estimates of survival and recovery rates for black ducks banded as young in Labrador & Eastern Quebec (020).*

| | | Males | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1962 | 56 | 41.36* | 11.26* | 6.08* | 1.47* |
| 1963 | 100 | | | | |
| 1964 | 107 | | | | |
| **Mean** | 263.00 | 41.36 | 11.26 | 6.08 | 1.47 |
| Total banded = 8,767 | | Total recoveries = 32 | | | $\chi^2$ = 15.45, 9 df |
| | | Model HO1 | | | |

* Average value.

Table C11. *Estimates of survival and recovery rates for black ducks banded as young in Southern Quebec (040).*

| | | Males | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1968 | 574 | 35.56* | 3.44* | 13.86 | 1.44 |
| 1969 | 339 | | | 17.29 | 2.04 |
| 1970 | 372 | | | 14.59 | 1.82 |
| 1971 | 669 | | | 11.74 | 1.24 |
| 1972 | 575 | | | 9.18 | 1.20 |
| 1973 | 458 | | | 7.81 | 1.25 |
| 1974 | 367 | | | 13.62 | 1.79 |
| 1975 | 364 | | | 11.18 | 1.65 |
| **Mean** | 464.75 | 35.56 | 3.44 | 12.41 | 0.56 |
| Total banded = 3,718 | | Total recoveries = 649 Model HO2 | | | $\chi^2$ = 65.53, 55 df |

| | | Females | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1968 | 450 | 43.20* | 7.34* | 12.30 | 1.55 |
| 1969 | 325 | | | 15.09 | 1.98 |
| 1970 | 244 | | | 13.14 | 2.16 |
| 1971 | 551 | | | 9.20 | 1.23 |
| **Mean** | 392.50 | 43.20 | 7.34 | 12.43 | 0.88 |
| Total banded = 1,570 | | Total recoveries = 270 Model HO2 | | | $\chi^2$ = 22.08, 22 df |

* Average value.

Table C12. *Estimates of survival and recovery rates for black ducks banded as young in Eastern Lake Ontario (120).*

| Males | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1950 | 131 | 76.45 | 28.22 | 5.34 | 1.96 |
| 1951 | 80 | 17.37 | 12.68 | 17.50 | 4.25 |
| 1952 | 279 | 29.90 | 8.69 | 10.39 | 1.83 |
| 1953 | 434 | | | 12.90 | 1.61 |
| **Mean** | 231.00 | 41.24 | 10.71 | 11.54 | 1.32 |
| Total banded = 924 | | Total recoveries = 164 | | | |
| | | Model H1 | | | |

| Males | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1960 | 507 | 43.61* | 2.66* | 15.71 | 1.61 |
| 1961 | 541 | | | 11.15 | 1.35 |
| 1962 | 428 | | | 11.16 | 1.52 |
| 1963 | 692 | | | 12.85 | 1.27 |
| 1964 | 683 | | | 12.63 | 1.27 |
| 1965 | 636 | | | 13.50 | 1.35 |
| 1966 | 731 | | | 14.99 | 1.31 |
| 1967 | 834 | | | 9.96 | 1.03 |
| 1968 | 658 | | | 10.71 | 1.20 |
| 1969 | 543 | | | 13.12 | 1.44 |
| 1970 | 884 | | | 11.44 | 1.07 |
| 1971 | 717 | | | 11.84 | 1.20 |
| 1972 | 337 | | | 11.59 | 1.74 |
| **Mean** | 630.08 | 43.61 | 2.66 | 12.36 | 0.38 |
| Total banded = 8,191 | | Total recoveries = 1,583 | | $\chi^2$ = 134.75, 118 df | |
| | | Model HO2 | | | |

* Average value.

Table C13. *Estimates of survival and recovery rates for black ducks banded as young in Eastern Lake Ontario (120).*

| | | Females | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1960 | 487 | 45.04 | 17.78 | 13.96 | 1.57 |
| 1961 | 516 | 41.39 | 12.25 | 11.63 | 1.41 |
| 1962 | 405 | 43.80 | 13.42 | 8.15 | 1.36 |
| 1963 | 492 | 66.16 | 24.00 | 11.99 | 1.46 |
| 1964 | 584 | 47.03 | 17.48 | 10.79 | 1.28 |
| 1965 | 513 | 24.63 | 8.60 | 11.11 | 1.39 |
| 1966 | 621 | 52.99 | 17.76 | 16.26 | 1.48 |
| 1967 | 627 | 26.09 | 10.98 | 13.56 | 1.37 |
| 1968 | 530 | 64.82 | 26.34 | 10.94 | 1.36 |
| 1969 | 455 | 42.61 | 18.94 | 11.65 | 1.50 |
| 1970 | 732 | 30.06 | 10.31 | 14.48 | 1.30 |
| 1971 | 517 | | | 12.96 | 1.48 |
| **Mean** | 539.92 | 44.06 | 5.14 | 12.29 | 0.41 |
| Total banded = 6,479 | | Total recoveries = 1,129 | | | |
| | | Model H2 | | | |

Table C14. *Estimates of survival and recovery rates for black ducks banded as young in Western Lake Ontario (130).*

| | | Males | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1965 | 674 | 44.49* | 3.83* | 13.24 | 1.30 |
| 1966 | 636 | | | 13.68 | 1.36 |
| 1967 | 677 | | | 10.38 | 1.17 |
| 1968 | 647 | | | 11.00 | 1.23 |
| 1969 | 428 | | | 14.82 | 1.71 |
| 1970 | 554 | | | 11.02 | 1.33 |
| 1971 | 644 | | | 11.54 | 1.26 |
| 1972 | 384 | | | 12.65 | 1.69 |
| **Mean** | 580.50 | 44.49 | 3.83 | 12.29 | 0.49 |
| Total banded = 4,644 | | Total recoveries = 885 | | | $\chi^2$ = 84.68, 65 df |
| | | Model HO2 | | | |

| | | Females | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1965 | 491 | 58.87* | 10.74* | 11.77 | 1.45 |
| 1966 | 436 | | | 12.60 | 1.58 |
| 1967 | 447 | | | 10.68 | 1.46 |
| 1968 | 475 | | | 10.42 | 1.40 |
| **Mean** | 462.25 | 58.87 | 10.74 | 11.37 | 0.74 |
| Total banded = 1,849 | | Total recoveries = 323 | | | $\chi^2$ = 24.46, 17 df |
| | | Model HO2 | | | |

* Average value.

Table C15. *Estimates of survival and recovery rates for black ducks banded as young in Upper Great Lakes (150).*

| Males | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1964 | 203 | 50.33* | 5.85* | 12.26 | 2.29 |
| 1965 | 201 | | | 20.08 | 2.11 |
| 1966 | 374 | | | 11.72 | 1.66 |
| 1967 | 395 | | | 8.26 | 1.38 |
| 1968 | 475 | | | 5.52 | 1.05 |
| **Mean** | 329.60 | 50.33 | 5.85 | 9.57 | 1.70 |
| Total banded = 1,648 | | Total recoveries = 290 | | | $\chi^2$ = 37.07, 37 df |
| | | Model HO2 | | | |

* Average value.

# Appendix D. Estimates of Survival and Recovery Rates for Black Ducks Banded as Adults and Young in the Preseason Period by Minor Reference Area of Banding.

Estimates of recovery and survival rates and their standard errors were made using the models for preseason banded adults and young (Program Brownie) as described in Brownie et al. (1978). The "best fit" model is presented. Mean values and their standard errors also are presented. The number banded by year and in total, and the total recoveries used in the analysis, are given as a guide to the quantity of data in each area. Test statistics for the goodness-of-fit of the models are given. Figure 2 in the text shows the location of each banding reference area.

Table D1. *Estimates of survival and recovery rates for black ducks banded as adults in Quebec (041).*

| Males | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1968 | 210 | 67.43* | 2.32* | 5.76 | 1.60 |
| 1969 | 220 | | | 8.23 | 1.21 |
| 1970 | 167 | | | 6.74 | 1.03 |
| 1971 | 163 | | | 5.78 | 0.93 |
| 1972 | 137 | | | 5.12 | 0.83 |
| 1973 | 91 | | | 5.97 | 0.94 |
| 1974 | 151 | | | 5.79 | 0.91 |
| 1975 | 165 | | | 7.19 | 1.05 |
| **Mean** | 163.00 | 67.43 | 2.32 | 6.32 | 0.49 |
| Total banded = 1,304 | | Total recoveries = 218 | | | $\chi^2$ = 66.21, 57 df |
| | | Model HO2 | | | |

| Females | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1968 | 199 | 60.04* | 5.10 | 8.90 | 2.01 |
| 1969 | 174 | | | 5.30 | 1.10 |
| 1970 | 131 | | | 4.80 | 1.05 |
| 1971 | 158 | | | 4.51 | 1.10 |
| **Mean** | 165.50 | 60.04 | 5.10 | 5.88 | 0.73 |
| Total banded = 662 | | Total recoveries = 89 | | | $\chi^2$ = 22.08, 22 df |
| | | Model HO2 | | | |

* Average value.

Table D2. *Estimates of survival and recovery rates for black ducks banded as adults in Massachusetts (081).*

| Females | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1969 | 243 | 41.11 | 16.19 | 5.35 | 1.44 |
| 1970 | 221 | 63.73 | 32.80 | 5.81 | 1.44 |
| 1971 | 159 | | | 2.30 | 1.00 |
| **Mean** | 207.66 | 52.42 | 16.47 | 4.49 | 0.76 |
| Total banded = 623 | | Total recoveries = 47 | | | $\chi^2$ = 5.51, 5 df |
| | | Model H1 | | | |

Table D3. *Estimates of survival and recovery rates for black ducks banded as adults in New York (122).*

| Males | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1960 | 238 | 59.06 | 13.83 | 6.72 | 1.62 |
| 1961 | 286 | 65.47 | 14.40 | 6.55 | 1.18 |
| 1962 | 223 | 46.52 | 10.90 | 6.45 | 1.22 |
| 1963 | 184 | 71.91 | 19.84 | 9.65 | 1.69 |
| 1964 | 170 | 34.99 | 8.67 | 4.72 | 1.11 |
| 1965 | 327 | 58.64 | 13.23 | 8.15 | 1.14 |
| 1966 | 119 | 67.47 | 19.59 | 8.79 | 1.79 |
| 1967 | 127 | 47.33 | 15.73 | 5.49 | 1.28 |
| 1968 | 69 | 51.06 | 14.90 | 7.49 | 1.99 |
| 1969 | 188 | 66.69 | 25.06 | 9.11 | 1.48 |
| 1970 | 41 | 56.47 | 23.47 | 7.30 | 2.61 |
| **Mean** | 179.27 | 56.92 | 3.05 | 7.31 | 0.49 |
| Total banded = 1,972 | | Total recoveries = 296 | | | $\chi^2$ = 68.34, 69 df |
| | | Model H1 | | | |

| Females | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1960 | 198 | 65.16 | 28.70 | | |
| 1961 | 208 | 36.43 | 13.80 | 1.85 | 0.98 |
| 1962 | 306 | 54.66 | 16.85 | 6.74 | 2.20 |
| 1963 | 279 | 95.82 | 38.45 | 5.07 | 1.59 |
| 1964 | 243 | 39.21 | 18.49 | 3.40 | 1.32 |
| 1965 | 190 | 26.27 | 11.41 | 3.81 | 1.50 |
| 1966 | 181 | | | 9.19 | 3.23 |
| **Mean** | 229.29 | 52.93 | 5.75 | 5.01 | 0.79 |
| Total banded = 1,605 | | Total recoveries = 235 | | | $\chi^2$ = 32.11, 27 df |
| | | Model H2 | | | |

Table D4. *Estimates of survival and recovery rates for black ducks banded as adults in Ontario (131).*

| | | Males | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1965 | 163 | 59.31* | 1.80* | 6.79* | 0.52* |
| 1966 | 115 | | | | |
| 1967 | 148 | | | | |
| 1968 | 105 | | | | |
| 1969 | 148 | | | | |
| 1970 | 141 | | | | |
| 1971 | 177 | | | | |
| 1972 | 170 | | | | |
| **Mean** | 145.88 | 59.31 | 1.80 | 6.79 | 0.52 |
| Total banded = 1,167 | | Total recoveries = 190 | | | $\chi^2$ = 14.66, 18 df |
| | | Model HO1 | | | |

* Average value.

Table D5. *Estimates of survival and recovery rates for black ducks banded as adults in Ontario (151).*

| | | Males | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1964 | 298 | 69.16* | 4.25* | 5.35 | 1.30 |
| 1965 | 117 | | | 5.44 | 1.15 |
| 1966 | 106 | | | 7.60 | 1.37 |
| 1967 | 134 | | | 6.92 | 1.30 |
| 1968 | 181 | | | 4.01 | 0.86 |
| **Mean** | 167.20 | 69.16 | 4.25 | 5.86 | 0.63 |
| Total banded = 836 | | Total recoveries = 135 | | | $\chi^2$ = 22.18, 29 df |
| | | Model HO2 | | | |

* Average value.

Table D6. *Estimates of survival and recovery rates for black ducks banded as young in Quebec (041).*

| Males | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1968 | 574 | 35.25* | 3.40* | 13.85 | 1.44 |
| 1969 | 339 | | | 17.29 | 2.04 |
| 1970 | 372 | | | 14.59 | 1.82 |
| 1971 | 669 | | | 11.74 | 1.24 |
| 1972 | 575 | | | 9.18 | 1.20 |
| 1973 | 458 | | | 7.81 | 1.25 |
| 1974 | 367 | | | 13.63 | 1.79 |
| 1975 | 364 | | | 11.18 | 1.65 |
| **Mean** | 464.75 | 35.25 | 3.40 | 12.41 | 0.56 |
| Total banded = 3,718 | | Total recoveries = 649 | | | $\chi^2$ = 66.21, 57 df |
| | | Model HO2 | | | |

| Females | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1968 | 450 | 43.20* | 7.34* | 12.30 | 1.55 |
| 1969 | 325 | | | 15.09 | 1.98 |
| 1970 | 244 | | | 13.14 | 2.16 |
| 1971 | 551 | | | 9.20 | 1.23 |
| **Mean** | 392.50 | 43.20 | 7.34 | 12.43 | 0.88 |
| Total banded = 1,570 | | Total recoveries = 270 | | | $\chi^2$ = 22.08, 22 df |
| | | Model HO2 | | | |

* Average value.

Table D7. *Estimates of survival and recovery rates for black ducks banded as young in Massachusetts (081).*

| Females | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1969 | 292 | 34.21 | 13.50 | 6.51 | 1.44 |
| 1970 | 316 | 36.17 | 21.62 | 8.86 | 1.60 |
| 1971 | 269 | | | 6.69 | 1.52 |
| **Mean** | 292.33 | 35.19 | 12.74 | 7.35 | 0.88 |
| Total banded = 877 | | Total recoveries = 90 | | | $\chi^2$ = 10.07, 7 df |
| | | Model H1 | | | |

Table D8. *Estimates of survival and recovery rates for black ducks banded as young in Eastern Lake Ontario–New York (122).*

| Males | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1960 | 501 | 38.58 | 8.24 | 15.97 | 1.64 |
| 1961 | 541 | 29.57 | 7.43 | 11.46 | 1.37 |
| 1962 | 428 | 38.28 | 8.89 | 11.21 | 1.53 |
| 1963 | 663 | 63.87 | 15.88 | 13.12 | 1.31 |
| 1964 | 647 | 40.71 | 7.01 | 12.52 | 1.30 |
| 1965 | 608 | 37.83 | 8.89 | 12.83 | 1.36 |
| 1966 | 602 | 59.53 | 14.70 | 13.62 | 1.40 |
| 1967 | 742 | 37.74 | 10.60 | 9.16 | 1.06 |
| 1968 | 524 | 37.79 | 7.55 | 10.69 | 1.35 |
| 1969 | 420 | 31.25 | 12.35 | 12.38 | 1.61 |
| 1970 | 231 | 50.02 | 15.40 | 14.29 | 2.30 |
| **Mean** | 537.00 | 41.52 | 3.35 | 12.48 | 0.45 |
| Total banded = 5,907 | | Total recoveries = 1,116 | | | $\chi^2$ = 68.34, 69 df |
| | | Model H1 | | | |

| Females | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1960 | 475 | 46.17 | 18.22 | 13.47 | 1.57 |
| 1961 | 516 | 41.39 | 12.25 | 11.63 | 1.41 |
| 1962 | 402 | 43.50 | 13.32 | 7.71 | 1.33 |
| 1963 | 472 | 67.43 | 26.53 | 11.23 | 1.45 |
| 1964 | 545 | 50.50 | 19.70 | 10.83 | 1.33 |
| 1965 | 495 | 16.81 | 6.46 | 10.51 | 1.38 |
| 1966 | 388 | | | 14.43 | 1.78 |
| **Mean** | 470.43 | 44.30 | 7.06 | 11.40 | 0.56 |
| Total banded = 3,293 | | Total recoveries = 535 | | | $\chi^2$ = 32.11, 27 df |
| | | Model H2 | | | |

Table D9. *Estimates of survival and recovery rates for black ducks banded as young in Western Lake Ontario–Ontario (131).*

| | | Males | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1965 | 360 | 41.36* | 3.71* | 11.01* | 0.50* |
| 1966 | 471 | | | | |
| 1967 | 597 | | | | |
| 1968 | 615 | | | | |
| 1969 | 359 | | | | |
| 1970 | 527 | | | | |
| 1971 | 577 | | | | |
| 1972 | 353 | | | | |
| **Mean** | 482.38 | 41.36 | 3.71 | 11.01 | 0.50 |
| Total banded = 3,859 | | Total recoveries = 682 | | | $\chi^2$ = 14.66, 18 df |
| | | Model HO1 | | | |

* Average value.

Table D10. *Estimates of survival and recovery rates for black ducks banded as young in Upper Great Lakes–Ontario (151).*

| | | Males | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1964 | 129 | 75.64* | 11.33* | 16.20 | 3.21 |
| 1965 | 122 | | | 9.77 | 2.67 |
| 1966 | 87 | | | 5.98 | 2.53 |
| 1967 | 158 | | | 9.97 | 2.37 |
| 1968 | 98 | | | 5.13 | 2.22 |
| **Mean** | 118.80 | 75.64 | 11.33 | 9.41 | 1.18 |
| Total banded = 594 | | Total recoveries = 126 | | | $\chi^2$ = 37.07, 37 df |
| | | Model HO2 | | | |

* Average value.

# Appendix E. Estimates of Survival and Recovery Rates for Black Ducks Banded as Adults in the Winter Period by State/Province of Banding.

Estimates of recovery and survival rates and their standard errors were made using the models for birds banded as adults (Program Estimate) as described in Brownie et al. (1978). The "best fit" model is presented. Mean values and their standard errors and an estimate of the mean life span and its standard error also are presented. The number banded by year and in total, and the total recoveries used in the analysis, are given as a guide to the quantity of data in each area. Test statistics for the goodness-of-fit of the models are given. Figure 3 in the text shows the location of each banding reference area.

Table E1. *Estimates of survival and recovery rates for black ducks banded as adults in Delaware (021).*

| | | Males | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1960 | 282 | 79.29 | 21.26 | 4.97 | 1.29 |
| 1961 | 214 | 66.60 | 17.18 | 2.92 | 0.89 |
| 1962 | 320 | 62.63 | 12.45 | 4.65 | 0.97 |
| 1963 | 830 | 120.49 | 26.44 | 4.66 | 0.65 |
| 1964 | 463 | 35.17 | 9.94 | 1.96 | 0.45 |
| 1965 | 208 | | | 3.42 | 0.85 |
| **Mean** | 386.17 | 72.84 | 5.26 | 3.76 | 0.40 |
| Total banded = 2,317 | | Total recoveries = 251 | | | $\chi^2$ = 14.84, 22 df |
| MLS = 3.16 ± 0.7 | | Model 1 | | | |

| | | Females | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1962 | 207 | 63.43* | 9.97* | 6.35 | 1.69 |
| 1963 | 554 | | | 3.06 | 0.67 |
| 1964 | 287 | | | 3.87 | 0.84 |
| 1965 | 123 | | | 1.90 | 0.69 |
| **Mean** | 292.75 | 63.43 | 9.97 | 3.80 | 0.56 |
| Total banded = 1,171 | | Total recoveries = 90 | | | $\chi^2$ = 6.70, 7 df |
| MLS = 2.20 ± 0.8 | | Model 2 | | | |

* Average value.

Table E2. *Estimates of survival and recovery rates for black ducks banded as adults in Illinois (034).*

| Males | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1969 | 1,140 | 67.24* | 3.86* | 3.69 | 0.56 |
| 1970 | 583 | | | 5.71 | 0.67 |
| 1971 | 432 | | | 4.31 | 0.62 |
| 1972 | 576 | | | 4.00 | 0.58 |
| **Mean** | 682.75 | 67.24 | 3.86 | 4.43 | 0.34 |
| Total banded = 2,731 | | Total recoveries = 331 | | | $\chi^2$ = 14.07, 16 df |
| MLS = 2.52 ± 0.4 | | Model H2 | | | |

| Females | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1969 | 896 | 59.50* | 2.99* | 3.16* | 0.32* |
| 1970 | 370 | | | | |
| 1971 | 313 | | | | |
| 1972 | 505 | | | | |
| **Mean** | 521.00 | 59.50 | 2.99 | 3.16 | 0.32 |
| Total banded = 2,084 | | Total recoveries = 159 | | | $\chi^2$ = 24.83, 20 df |
| MLS = 1.93 ± 0.2 | | Model 3 | | | |

* Average value.

Table E3. *Estimates of survival and recovery rates for black ducks banded as adults in Maine (044).*

| Males | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1960 | 571 | 64.39 | 8.99 | 8.93 | 1.19 |
| 1961 | 403 | 97.15 | 17.85 | 5.04 | 0.85 |
| 1962 | 213 | 88.97 | 24.91 | 6.01 | 1.11 |
| 1963 | 146 | | | 4.06 | 1.17 |
| **Mean** | 333.25 | 83.50 | 7.52 | 6.01 | 0.61 |
| Total banded = 1,333 | | Total recoveries = 273 | | | $\chi^2$ = 6.41, 12 df |
| MLS = 5.55 ± 2.8 | | Model 1 | | | |

| Females | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1960 | 317 | 38.51 | 10.68 | 6.63 | 1.40 |
| 1961 | 176 | 109.82 | 39.40 | 6.63 | 1.61 |
| 1962 | 141 | | | 4.60 | 1.47 |
| **Mean** | 211.33 | 74.16 | 18.79 | 5.95 | 1.07 |
| Total banded = 634 | | Total recoveries = 80 | | | $\chi^2$ = 3.94, 4 df |
| MLS = 3.35 ± 2.8 | | Model 1 | | | |

Table E4. *Estimates of survival and recovery rates for black ducks banded as adults in Maryland (046).*

| | | Males | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1967 | 302 | 70.13* | 2.91* | 5.25 | 1.28 |
| 1968 | 345 | | | 3.55 | 0.79 |
| 1969 | 461 | | | 5.43 | 0.80 |
| 1970 | 289 | | | 3.39 | 0.63 |
| 1971 | 488 | | | 2.63 | 0.50 |
| 1972 | 457 | | | 3.50 | 0.56 |
| 1973 | 451 | | | 3.64 | 0.57 |
| **Mean** | 399.00 | 70.13 | 2.91 | 3.91 | 0.31 |
| Total banded = 2,793 | | Total recoveries = 315 | | | $\chi^2$ = 40.20, 33 df |
| MLS = 2.82 ± 0.3 | | Model 2 | | | |

| | | Females | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1957 | 153 | 59.32* | 3.03* | 3.54* | 0.39* |
| 1958 | 284 | | | | |
| 1959 | 150 | | | | |
| 1960 | 206 | | | | |
| 1961 | 295 | | | | |
| 1962 | 253 | | | | |
| 1963 | 167 | | | | |
| **Mean** | 215.43 | 59.32 | 3.03 | 3.54 | 0.39 |
| Total banded = 1,508 | | Total recoveries = 130 | | | $\chi^2$ = 33.40, 30 df |
| MLS = 1.91 ± 0.2 | | Model 3 | | | |

* Average value.

Table E5. *Estimates of survival and recovery rates for black ducks banded as adults in Maryland (046).*

| | | Females | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1967 | 176 | 54.44* | 3.45* | 3.39* | 0.39* |
| 1968 | 209 | | | | |
| 1969 | 271 | | | | |
| 1970 | 130 | | | | |
| 1971 | 297 | | | | |
| 1972 | 329 | | | | |
| 1973 | 340 | | | | |
| **Mean** | 250.29 | 54.44 | 3.45 | 3.39 | 0.39 |
| Total banded = 1,752 | | Total recoveries = 128 | | | $\chi^2$ = 28.04, 25 df |
| MLS = 1.64 ± 0.2 | | Model 3 | | | |

* Average value.

Table E6. *Estimates of survival and recovery rates for black ducks banded as adults in Massachusetts (047).*

| | | Males | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1939 | 453 | 77.23* | 6.83* | 4.59 | 0.98 |
| 1940 | 642 | | | 3.64 | 0.61 |
| 1941 | 199 | | | 3.22 | 0.65 |
| 1942 | 415 | | | 2.33 | 0.52 |
| **Mean** | 427.25 | 77.23 | 6.83 | 3.44 | 0.38 |
| Total banded = 1,709 | | Total recoveries = 163 | | | $\chi^2$ = 14.01, 13 df |
| MLS = 3.87 ± 1.3 | | Model 2 | | | |

| | | Males | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1967 | 1,116 | 82.55 | 11.20 | 3.32 | 0.54 |
| 1968 | 1,259 | 56.08 | 6.71 | 2.54 | 0.36 |
| 1969 | 1,514 | 74.83 | 8.49 | 3.57 | 0.39 |
| 1970 | 1,310 | 79.49 | 11.23 | 3.74 | 0.40 |
| 1971 | 890 | 84.32 | 19.55 | 2.44 | 0.35 |
| 1972 | 331 | 84.78 | 27.53 | 2.16 | 0.48 |
| 1973 | 282 | 64.83 | 22.91 | 1.71 | 0.47 |
| 1974 | 304 | | | 2.50 | 0.65 |
| **Mean** | 888.25 | 75.27 | 2.90 | 2.75 | 0.16 |
| Total banded = 7,106 | | Total recoveries = 688 | | | $\chi^2$ = 52.14, 37 df |
| MLS = 3.52 ± 0.5 | | Model 1 | | | |

Table E7. *Estimates of survival and recovery rates for black ducks banded as adults in Massachusetts (047).*

| | | Females | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1963 | 233 | 42.49 | 18.14 | 2.15 | 0.95 |
| 1964 | 197 | 23.72 | 11.07 | 5.30 | 1.50 |
| 1965 | 173 | 73.23 | 21.17 | 2.41 | 1.02 |
| 1966 | 856 | 100.75 | 22.90 | 4.13 | 0.65 |
| 1967 | 612 | 26.76 | 6.10 | 2.42 | 0.51 |
| 1968 | 1,164 | 98.01 | 17.58 | 3.46 | 0.48 |
| 1969 | 836 | 47.12 | 8.60 | 2.04 | 0.37 |
| 1970 | 1,207 | 56.53 | 10.60 | 3.62 | 0.46 |
| 1971 | 623 | 83.49 | 28.86 | 2.61 | 0.47 |
| 1972 | 198 | 44.45 | 21.67 | 2.23 | 0.73 |
| 1973 | 125 | 48.57 | 22.85 | 2.01 | 0.81 |
| 1974 | 175 | 94.71 | 37.16 | 2.72 | 0.89 |
| 1975 | 365 | 37.16 | 15.33 | 2.62 | 0.72 |
| 1976 | 374 | | | 2.90 | 0.81 |
| **Mean** | 509.86 | 59.77 | 3.27 | 2.90 | 0.22 |
| Total banded = 7,138 | | Total recoveries = 505 | | | $\chi^2$ = 35.00, 38 df |
| MLS = 1.94 ± 0.2 | | Model 1 | | | |

Table E8. *Estimates of survival and recovery rates for black ducks banded as adults in Michigan (049).*

| | | Males | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1967 | 165 | 68.90* | 3.59* | 4.34* | 0.60* |
| 1968 | 365 | | | | |
| 1969 | 138 | | | | |
| **Mean** | 222.67 | 68.90 | 3.59 | 4.34 | 0.60 |
| Total banded = 668 | | Total recoveries = 90 | | | $\chi^2$ = 12.37, 17 df |
| MLS = 2.68 | | Model 3 | | | |

* Average value.

Table E9. *Estimates of survival and recovery rates for black ducks banded as adults in New Jersey (059).*

| | | Males | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1952 | 167 | 82.37 | 23.70 | 8.38 | 2.15 |
| 1953 | 180 | 75.95 | 24.17 | 5.27 | 1.41 |
| 1954 | 178 | 40.47 | 12.92 | 4.83 | 1.32 |
| 1955 | 221 | 70.43 | 19.61 | 3.73 | 1.04 |
| 1956 | 188 | 50.90 | 12.67 | 4.56 | 1.18 |
| 1957 | 417 | | | 4.96 | 0.91 |
| **Mean** | 225.17 | 64.02 | 5.09 | 5.29 | 0.66 |
| Total banded = 1,351 | | Total recoveries = 188 | | | $\chi^2$ = 15.49, 20 df |
| MLS = 2.24 ± 0.4 | | Model 1 | | | |

| | | Males | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1959 | 231 | 63.88 | 16.47 | 6.06 | 1.57 |
| 1960 | 995 | 72.39 | 21.18 | 4.72 | 0.65 |
| 1961 | 167 | | | 2.09 | 0.67 |
| **Mean** | 464.33 | 68.13 | 12.68 | 4.29 | 0.85 |
| Total banded = 1,393 | | Total recoveries = 150 | | | $\chi^2$ = 6.90, 9 df |
| MLS = 2.61 ± 1.26 | | Model 1 | | | |

Table E10. *Estimates of survival and recovery rates for black ducks banded as adults in New Jersey (059).*

| Males | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1963 | 781 | 68.79* | 1.16* | 5.29 | 0.80 |
| 1964 | 222 | | | 3.51 | 0.67 |
| 1965 | 259 | | | 2.80 | 0.60 |
| 1966 | 696 | | | 3.96 | 0.56 |
| 1967 | 816 | | | 3.82 | 0.48 |
| 1968 | 1,309 | | | 5.18 | 0.46 |
| 1969 | 804 | | | 3.68 | 0.39 |
| 1970 | 1,339 | | | 3.80 | 0.36 |
| 1971 | 565 | | | 3.08 | 0.35 |
| 1972 | 594 | | | 4.32 | 0.45 |
| 1973 | 580 | | | 4.30 | 0.46 |
| 1974 | 526 | | | 2.98 | 0.40 |
| 1975 | 217 | | | 3.22 | 0.47 |
| 1976 | 606 | | | 4.49 | 0.54 |
| **Mean** | 665.29 | 68.79 | 1.16 | 3.89 | 0.16 |
| Total banded = 9,314 | | Total recoveries = 1,039 | | | $\chi^2$ = 82.81, 77 df |
| MLS = 2.67 ± 0.1 | | Model 2 | | | |

| Females | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1965 | 198 | 60.91* | 1.89* | 3.26 | 1.33 |
| 1966 | 495 | | | 4.06 | 0.80 |
| 1967 | 415 | | | 3.02 | 0.61 |
| 1968 | 793 | | | 2.92 | 0.48 |
| 1969 | 585 | | | 2.96 | 0.47 |
| 1970 | 996 | | | 3.27 | 0.43 |
| 1971 | 581 | | | 2.85 | 0.42 |
| 1972 | 427 | | | 3.17 | 0.49 |
| 1973 | 517 | | | 3.06 | 0.49 |
| 1974 | 404 | | | 3.41 | 0.55 |
| 1975 | 169 | | | 1.92 | 0.47 |
| 1976 | 540 | | | 4.60 | 0.67 |
| **Mean** | 509.17 | 60.91 | 1.89 | 3.24 | 0.21 |
| Total banded = 6,110 | | Total recoveries = 459 | | | $\chi^2$ = 41.66, 46 df |
| MLS = 2.02 ± 0.1 | | Model 2 | | | |

* Average value.

Table E11. *Estimates of survival and recovery rates for black ducks banded as adults in New York (061).*

| | | Males | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1957 | 562 | 52.57 | 12.81 | 3.56 | 0.78 |
| 1958 | 251 | 50.90 | 11.82 | 5.04 | 1.14 |
| 1959 | 831 | 85.50 | 14.61 | 2.87 | 0.52 |
| 1960 | 481 | 51.81 | 9.49 | 3.79 | 0.65 |
| 1961 | 587 | 59.77 | 11.69 | 3.41 | 0.57 |
| 1962 | 233 | 57.17 | 11.27 | 5.57 | 1.04 |
| 1963 | 471 | 80.79 | 11.65 | 4.16 | 0.69 |
| 1964 | 708 | 66.51 | 8.92 | 5.22 | 0.66 |
| 1965 | 763 | 64.55 | 8.81 | 6.01 | 0.69 |
| 1966 | 801 | 54.74 | 8.11 | 3.42 | 0.47 |
| 1967 | 383 | 103.83 | 14.23 | 4.78 | 0.72 |
| 1968 | 1,436 | 43.92 | 4.77 | 4.59 | 0.45 |
| 1969 | 941 | 80.74 | 9.49 | 5.36 | 0.56 |
| 1970 | 775 | 102.11 | 18.47 | 6.47 | 0.67 |
| 1971 | 515 | 46.22 | 9.65 | 2.34 | 0.42 |
| 1972 | 408 | 64.51 | 15.75 | 4.86 | 0.77 |
| 1973 | 241 | 59.43 | 14.92 | 3.32 | 0.75 |
| 1974 | 366 | 124.30 | 50.87 | 5.70 | 0.97 |
| 1975 | 189 | 22.14 | 9.37 | 1.88 | 0.73 |
| 1976 | 411 | | | 8.03 | 1.34 |
| **Mean** | 567.65 | 66.92 | 2.42 | 4.52 | 0.17 |
| Total banded = 11,353 | | Total recoveries = 1,447 | | | $\chi^2$ = 114.05, 106 df |
| MLS = 2.49 ± 0.2 | | Model 1 | | | |

Table E12. *Estimates of survival and recovery rates for black ducks banded as adults in New York (061).*

| | | Females | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1959 | 581 | 50.47* | 3.30* | 4.83* | 0.51 |
| 1960 | 407 | | | | |
| 1961 | 362 | | | | |
| **Mean** | 450.00 | 50.47 | 3.30 | 4.83 | 0.51 |
| Total banded = 1,350 | | Total recoveries = 131 | | | $\chi^2$ = 21.31, 12 df |
| MLS = 1.46 ± 0.1 | | Model 3 | | | |

| | | Females | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1963 | 263 | 55.19* | 2.17* | 4.26 | 1.24 |
| 1964 | 407 | | | 4.90 | 0.92 |
| 1965 | 436 | | | 4.72 | 0.79 |
| 1966 | 472 | | | 4.09 | 0.68 |
| 1967 | 267 | | | 2.51 | 0.68 |
| 1968 | 1,075 | | | 4.01 | 0.52 |
| 1969 | 624 | | | 3.94 | 0.53 |
| 1970 | 449 | | | 4.58 | 0.64 |
| 1971 | 225 | | | 3.18 | 0.62 |
| 1972 | 178 | | | 5.87 | 1.01 |
| **Mean** | 439.60 | 55.19 | 2.17 | 4.21 | 0.28 |
| Total banded = 4,396 | | Total recoveries = 413 | | | $\chi^2$ = 35.36, 37 df |
| MLS = 1.68 ± 0.1 | | | | | |

Table E13. *Estimates of survival and recovery rates for black ducks banded as adults in North Carolina (063).*

Males

| Year | Number banded | Survival | S.E. | Recovery | S.E. |
|---|---|---|---|---|---|
| 1962 | 176 | 68.51* | 2.43* | 2.23 | 1.11 |
| 1963 | 141 | | | 2.29 | 0.93 |
| 1964 | 424 | | | 3.21 | 0.72 |
| 1965 | 418 | | | 2.54 | 0.55 |
| 1966 | 231 | | | 3.10 | 0.63 |
| 1967 | 197 | | | 2.27 | 0.56 |
| 1968 | 246 | | | 2.76 | 0.62 |
| 1969 | 401 | | | 3.14 | 0.60 |
| 1970 | 193 | | | 1.82 | 0.49 |
| 1971 | 381 | | | 4.46 | 0.73 |
| 1972 | 197 | | | 2.73 | 0.60 |
| **Mean** | 273.18 | 68.51 | 2.43 | 2.78 | 0.24 |

Total banded = 3,005 Total recoveries = 259 $\chi^2$ = 52.99, 53 df

MLS = 2.64 ± 0.3 Model 2

Females

| Year | Number banded | Survival | S.E. | Recovery | S.E. |
|---|---|---|---|---|---|
| 1963 | 140 | 9.26 | 9.39 | 3.57 | 1.57 |
| 1964 | 349 | 34.69 | 13.20 | 4.69 | 1.12 |
| 1965 | 263 | 78.86 | 33.52 | 2.54 | 0.85 |
| 1966 | 139 | 55.50 | 29.61 | 2.67 | 1.07 |
| 1967 | 143 | 63.64 | 35.11 | 2.00 | 0.90 |
| 1968 | 175 | 24.77 | 10.75 | 1.40 | 0.67 |
| 1969 | 361 | 45.40 | 12.98 | 4.51 | 1.01 |
| 1970 | 173 | 83.69 | 26.51 | 6.19 | 1.54 |
| 1971 | 365 | 59.63 | 23.75 | 3.08 | 0.77 |
| 1972 | 157 | | | 2.71 | 1.00 |
| **Mean** | 226.50 | 50.60 | 4.45 | 3.34 | 0.37 |

Total banded = 2,265 Total recoveries = 166 $\chi^2$ = 27.68, 17 df

MLS = 1.47 ± 0.2 Model 1

Table E14. *Estimates of survival and recovery rates for black ducks banded as adults in Ohio (066).*

| Males | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1969 | 224 | 57.59 | 15.94 | 5.36 | 1.50 |
| 1970 | 128 | 90.78 | 22.99 | 5.34 | 1.58 |
| 1971 | 413 | 86.16 | 21.82 | 5.65 | 1.00 |
| 1972 | 299 | 33.18 | 11.22 | 3.84 | 0.89 |
| 1973 | 118 | 70.92 | 23.61 | 5.58 | 1.63 |
| 1974 | 349 | | | 3.77 | 0.87 |
| **Mean** | 255.17 | 67.73 | 5.57 | 4.92 | 0.61 |
| Total banded = 1,531 | | Total recoveries = 178 | | | $\chi^2$ = 14.89, 16 df |
| MLS = 2.57 ± 0.5 | | Model 1 | | | |

| Females | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1971 | 183 | 48.11* | 8.17* | 2.22 | 1.09 |
| 1972 | 146 | | | 5.90 | 1.60 |
| 1973 | 109 | | | 4.93 | 1.58 |
| 1974 | 209 | | | 3.18 | 1.03 |
| **Mean** | 161.75 | 48.11 | 8.17 | 4.06 | 0.72 |
| Total banded = 647 | | Total recoveries = 57 | | | $\chi^2$ = 2.90, 5 df |
| MLS = 1.37 ± 0.3 | | Model 2 | | | |

* Average value.

Table E15. *Estimates of survival and recovery rates for black ducks banded as adults in Tennessee (082).*

| Males | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1963 | 655 | 65.40 | 9.51 | 3.36 | 0.70 |
| 1964 | 911 | 63.39 | 8.82 | 4.77 | 0.62 |
| 1965 | 553 | 70.20 | 9.31 | 4.18 | 0.63 |
| 1966 | 997 | 85.74 | 9.39 | 4.41 | 0.52 |
| 1967 | 1,340 | 68.59 | 7.93 | 4.58 | 0.45 |
| 1968 | 1,107 | 57.64 | 6.59 | 3.39 | 0.39 |
| 1969 | 1,137 | 83.44 | 8.88 | 4.50 | 0.46 |
| 1970 | 1,740 | 58.96 | 6.71 | 4.34 | 0.41 |
| 1971 | 1,037 | 92.46 | 13.89 | 3.91 | 0.43 |
| 1972 | 656 | | | 3.38 | 0.48 |
| **Mean** | 986.30 | 71.76 | 1.82 | 4.08 | 0.17 |
| Total banded = 9,863 | | Total recoveries = 1,281 | | | $\chi^2$ = 68.75, 66 df |
| MLS = 3.01 ± 0.2 | | Model 1 | | | |

| Females | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1963 | 386 | 59.54* | 1.76* | 5.99 | 1.21 |
| 1964 | 659 | | | 5.36 | 0.76 |
| 1965 | 362 | | | 3.81 | 0.65 |
| 1966 | 640 | | | 4.64 | 0.63 |
| 1967 | 1,020 | | | 4.63 | 0.52 |
| 1968 | 805 | | | 3.57 | 0.45 |
| 1969 | 744 | | | 3.84 | 0.47 |
| 1970 | 1,024 | | | 4.22 | 0.46 |
| 1971 | 821 | | | 3.27 | 0.41 |
| 1972 | 531 | | | 3.95 | 0.50 |
| **Mean** | 669.20 | 59.54 | 1.76 | 4.33 | 0.22 |
| Total banded = 6,992 | | Total recoveries = 672 | | | $\chi^2$ = 42.04, 50 df |
| MLS = 1.93 ± 0.1 | | Model 2 | | | |

* Average value.

Table E16. *Estimates of survival and recovery rates for black ducks banded as adults in Virginia (088).*

| | | Males | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1965 | 204 | 29.95 | 11.22 | 2.45 | 1.08 |
| 1966 | 335 | 72.73 | 17.16 | 4.53 | 1.07 |
| 1967 | 323 | 92.52 | 18.42 | 2.10 | 0.62 |
| 1968 | 807 | 66.26 | 14.45 | 3.17 | 0.52 |
| 1969 | 295 | 49.93 | 11.04 | 2.65 | 0.62 |
| 1970 | 481 | 61.50 | 12.49 | 3.60 | 0.64 |
| 1971 | 210 | 108.54 | 32.08 | 6.15 | 1.17 |
| 1972 | 192 | | | 3.07 | 0.84 |
| **Mean** | 355.88 | 68.77 | 4.69 | 3.47 | 0.32 |
| Total banded = 2,847 | | Total recoveries = 312 | | | $\chi^2$ = 42.73, 38 df |
| MLS = 2.67 ± 0.5 | | Model 1 | | | |

| | | Females | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1965 | 184 | 67.71* | 2.71* | 2.54* | 0.27* |
| 1966 | 283 | | | | |
| 1967 | 272 | | | | |
| 1968 | 630 | | | | |
| 1969 | 210 | | | | |
| 1970 | 372 | | | | |
| 1971 | 173 | | | | |
| **Mean** | 303.43 | 67.71 | 2.71 | 2.54 | 0.27 |
| Total banded = 2,124 | | Total recoveries = 161 | | | $\chi^2$ = 31.24, 37 df |
| MLS = 2.56 ± 0.3 | | Model 3 | | | |

* Average value.

# Appendix F. Estimates of Survival and Recovery Rates for Black Ducks Banded as Adults in the Winter Period by Major Reference Area of Banding.

Estimates of recovery and survival rates and their standard errors were made using the models for birds banded as adults (Program Estimate) as described in Brownie et al. (1978). The "best fit" model is presented. Mean values and their standard errors and an estimate of the mean life span and its standard error also are presented. The number banded by year and in total, and the total recoveries used in the analysis, are given as a guide to the quantity of data in each area. Test statistics for the goodness-of-fit of the models are given. Figure 3 in the text shows the location of each banding reference area.

Table F1. *Estimates of survival and recovery rates for black ducks banded as adults in the Maritimes (010).*

| | | Males | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1971 | 212 | 55.41 | 11.54 | 3.79 | 1.31 |
| 1972 | 248 | | | 2.73 | 0.88 |
| 1973 | 203 | | | 3.45 | 1.02 |
| **Mean** | 221.00 | 55.41 | 11.54 | 3.32 | 0.64 |
| Total banded = 663 | | Total recoveries = 54 | | | $\chi^2$ = 7.30, 7 df |
| MLS = 1.69 ± 0.6 | | Model 2 | | | |

Table F2. *Estimates of survival and recovery rates for black ducks banded as adults in Maine (020).*

Males

| Year | Number banded | Survival | S.E. | Recovery | S.E. |
|---|---|---|---|---|---|
| 1960 | 571 | 64.39 | 8.99 | 8.93 | 1.19 |
| 1961 | 403 | 97.15 | 17.85 | 5.04 | 0.85 |
| 1962 | 213 | 88.97 | 24.91 | 6.01 | 1.11 |
| 1963 | 146 | | | 4.60 | 1.17 |
| **Mean** | 333.25 | 83.50 | 7.52 | 6.15 | 0.61 |

Total banded = 1,333 Total recoveries = 273 $\chi^2$ = 6.41, 12 df

MLS = 5.55 ± 2.8 Model 1

Females

| Year | Number banded | Survival | S.E. | Recovery | S.E. |
|---|---|---|---|---|---|
| 1960 | 317 | 38.51 | 10.68 | 6.63 | 1.40 |
| 1961 | 176 | 109.82 | 39.40 | 6.63 | 1.61 |
| 1962 | 141 | | | 4.60 | 1.47 |
| **Mean** | 211.33 | 74.16 | 18.79 | 5.95 | 1.07 |

Total banded = 634 Total recoveries = 80 $\chi^2$ = 3.94, 4 df

MLS = 3.35 ± 2.8 Model 1

Table F3. *Estimates of survival and recovery rates for black ducks banded as adults in the Southern New England (030).*

| | | Males | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1968 | 2,583 | 55.67 | 6.24 | | |
| 1969 | 2,037 | 98.16 | 12.64 | 4.05 | 0.70 |
| 1970 | 1,592 | 84.88 | 14.34 | 2.88 | 0.45 |
| 1971 | 1,041 | 69.47 | 19.48 | 1.71 | 0.32 |
| 1972 | 331 | 107.42 | 45.94 | 2.20 | 0.61 |
| 1973 | 282 | 43.14 | 20.39 | 1.17 | 0.45 |
| 1974 | 304 | 96.04 | 41.61 | 2.68 | 0.94 |
| 1975 | 706 | 72.20 | 38.15 | 1.44 | 0.51 |
| 1976 | 891 | | | 1.29 | 0.63 |
| **Mean** | 1,085.22 | 78.37 | 5.75 | 2.18 | 0.21 |
| Total banded = 9,767 | | Total recoveries = 966 | | | $\chi^2$ = 29.28, 25 df |
| MLS = 4.10 ± 1.2 | | Model 0 | | | |

| | | Males | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1972 | 331 | 58.24* | 5.59* | 2.14 | 0.80 |
| 1973 | 282 | | | 2.94 | 0.79 |
| 1974 | 304 | | | 2.05 | 0.61 |
| 1975 | 706 | | | 4.70 | 0.70 |
| 1976 | 891 | | | 3.07 | 0.48 |
| **Mean** | 502.80 | 58.24 | 5.59 | 2.98 | 0.33 |
| Total banded = 2,514 | | Total recoveries = 144 | | | $\chi^2$ = 11.80, 9 df |
| MLS = 1.85 ± 0.3 | | Model 2 | | | |

* Average value.

Table F4. *Estimates of survival and recovery rates for black ducks banded as adults in Southern New England (030).*

| Females | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1939 | 185 | 48.41* | 9.23* | 5.47 | 1.67 |
| 1940 | 359 | | | 5.09 | 1.06 |
| 1941 | 194 | | | 3.16 | 0.95 |
| 1942 | 229 | | | 3.51 | 1.02 |
| **Mean** | 241.75 | 48.41 | 9.23 | 4.31 | 0.64 |
| Total banded = 967 | | Total recoveries = 66 | | | $\chi^2$ = 3.13, 4 df |
| MLS = 1.38 ± 0.4 | | Model 2 | | | |

| Females | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1963 | 465 | 58.71 | 23.26 | 3.44 | 0.85 |
| 1964 | 545 | 47.86 | 11.09 | 5.23 | 0.88 |
| 1965 | 555 | 53.47 | 10.04 | 3.56 | 0.68 |
| 1966 | 1,457 | 87.65 | 15.23 | 3.91 | 0.47 |
| 1967 | 838 | 36.43 | 6.21 | 2.54 | 0.42 |
| 1968 | 2,091 | 76.46 | 10.28 | 3.65 | 0.37 |
| 1969 | 1,233 | 56.42 | 8.39 | 2.68 | 0.35 |
| 1970 | 1,391 | 48.77 | 8.31 | 3.59 | 0.41 |
| 1971 | 688 | 93.89 | 31.77 | 2.80 | 0.46 |
| 1972 | 198 | 45.12 | 21.89 | 2.19 | 0.71 |
| 1973 | 125 | 47.50 | 22.26 | 2.09 | 0.82 |
| 1974 | 175 | 90.68 | 35.46 | 2.89 | 0.91 |
| 1975 | 365 | 38.96 | 15.33 | 2.53 | 0.70 |
| 1976 | 418 | | | 2.98 | 0.78 |
| **Mean** | 753.14 | 60.15 | 2.66 | 3.16 | 0.18 |
| Total banded = 10,544 | | Total recoveries = 817 | | | $\chi^2$ = 55.44, 46 df |
| MLS = 1.97 ± 0.2 | | Model 1 | | | |

* Average value.

Table F5. *Estimates of survival and recovery rates for black ducks banded as adults in Western Long Island–Hudson River (040).*

| Males | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1957 | 418 | 73.79* | 8.02* | 1.34* | 0.35* |
| 1958 | 104 | | | | |
| 1959 | 171 | | | | |
| **Mean** | 231.00 | 73.79 | 8.02 | 1.34 | 0.35 |
| Total banded = 693 | | Total recoveries = 30 | | | $\chi^2$ = 12.32, 10 df |
| MLS = 3.29 ± 1.2 | | Model 3 | | | |

* Average value.

Table F6. *Estimates of survival and recovery rates for black ducks banded as adults in the Mid-Atlantic (050).*

| | | Males | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1952 | 153 | 63.01* | 3.25* | 4.63* | 0.58* |
| 1953 | 163 | | | | |
| 1954 | 119 | | | | |
| 1955 | 145 | | | | |
| 1956 | 225 | | | | |
| **Mean** | 161.00 | 63.01 | 3.25 | 4.63 | 0.58 |
| Total banded = 805 | | Total recoveries = 100 | | | $\chi^2$ = 22.03, 24 df |
| MLS = 2.16 ± 0.2 | | Model 3 | | | |

| | | Males | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1957 | 1,114 | 67.47* | 0.88* | 5.38 | 0.68 |
| 1958 | 1,137 | | | 4.84 | 0.50 |
| 1959 | 197 | | | 3.47 | 0.48 |
| 1960 | 271 | | | 3.82 | 0.55 |
| 1961 | 566 | | | 2.90 | 0.45 |
| 1962 | 558 | | | 4.20 | 0.53 |
| 1963 | 1,042 | | | 3.59 | 0.42 |
| 1964 | 698 | | | 3.31 | 0.40 |
| 1965 | 862 | | | 2.81 | 0.35 |
| 1966 | 598 | | | 3.09 | 0.39 |
| 1967 | 766 | | | 2.87 | 0.36 |
| 1968 | 1,102 | | | 3.84 | 0.39 |
| 1969 | 1,214 | | | 3.88 | 0.37 |
| 1970 | 866 | | | 2.81 | 0.32 |
| 1971 | 1,082 | | | 4.30 | 0.39 |
| 1972 | 839 | | | 3.66 | 0.37 |
| 1973 | 644 | | | 2.71 | 0.33 |
| 1974 | 160 | | | 3.93 | 0.47 |
| 1975 | 153 | | | 2.99 | 0.47 |
| 1976 | 522 | | | 4.22 | 0.55 |
| **Mean** | 719.55 | 67.47 | 0.88 | 3.63 | 0.12 |
| Total banded = 14,391 | | Total recoveries = 1,472 | | | $\chi^2$ = 120.48, 121 df |
| MLS = 2.54 ± 0.1 | | Model 2 | | | |

* Average value.

Table F7. *Estimates of survival and recovery rates for black ducks banded as adults in the Mid-Atlantic (050).*

| | | Females | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1964 | 554 | 36.21 | 9.48 | 5.78 | 0.99 |
| 1965 | 548 | 75.21 | 18.50 | 3.46 | 0.71 |
| 1966 | 359 | 51.83 | 13.73 | 3.50 | 0.79 |
| 1967 | 514 | 83.71 | 19.46 | 2.86 | 0.61 |
| 1968 | 760 | 40.51 | 8.27 | 2.03 | 0.41 |
| 1969 | 844 | 44.65 | 8.17 | 3.97 | 0.58 |
| 1970 | 635 | 88.64 | 16.79 | 4.09 | 0.65 |
| 1971 | 843 | 71.81 | 15.78 | 2.56 | 0.43 |
| 1972 | 632 | 47.58 | 12.48 | 2.72 | 0.52 |
| 1973 | 489 | | | 2.21 | 0.50 |
| **Mean** | 617.80 | 60.02 | 2.59 | 3.32 | 0.22 |

Total banded = 6,178 Total recoveries = 465 $\chi^2$ = 42.76, 33 df

MLS = 1.96 ± 0.2 Model 1

Table F8. *Estimates of survival and recovery rates for black ducks banded as adults in the Mid-Atlantic (060).*

| Males | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1952 | 167 | 68.43* | 8.01* | 8.53 | 2.16 |
| 1953 | 180 | | | 7.78 | 1.40 |
| 1954 | 178 | | | 5.47 | 1.27 |
| 1955 | 201 | | | 3.04 | 0.87 |
| **Mean** | 181.50 | 68.43 | 8.01 | 6.20 | 0.77 |
| Total banded = 726 | | Total recoveries = 99 | | | $\chi^2$ = 10.41, 12 df |
| MLS = 2.64 ± 0.8 | | Model 2 | | | |

| Males | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1959 | 261 | 67.64* | 0.91* | 5.73 | 1.44 |
| 1960 | 1,152 | | | 4.94 | 0.60 |
| 1961 | 308 | | | 2.39 | 0.44 |
| 1962 | 425 | | | 3.62 | 0.54 |
| 1963 | 964 | | | 4.40 | 0.49 |
| 1964 | 486 | | | 2.68 | 0.40 |
| 1965 | 454 | | | 2.65 | 0.41 |
| 1966 | 807 | | | 4.10 | 0.47 |
| 1967 | 1,067 | | | 3.26 | 0.39 |
| 1968 | 1,607 | | | 4.71 | 0.39 |
| 1969 | 798 | | | 3.75 | 0.36 |
| 1970 | 1,554 | | | 3.75 | 0.33 |
| 1971 | 596 | | | 3.04 | 0.33 |
| 1972 | 601 | | | 4.10 | 0.41 |
| 1973 | 600 | | | 4.52 | 0.45 |
| 1974 | 528 | | | 3.08 | 0.39 |
| 1975 | 252 | | | 3.53 | 0.47 |
| 1976 | 700 | | | 4.59 | 0.51 |
| **Mean** | 1,012.31 | 67.64 | 0.91 | 3.82 | 0.15 |
| Total banded = 13,160 | | Total recoveries = 1,415 | | | $\chi^2$ = 126.49, 112 df |
| MLS = 2.56 ± 0.1 | | Model 2 | | | |

* Average value.

Table F9. *Estimates of survival and recovery rates for black ducks banded as adults in the Mid-Atlantic Coastal (060).*

| | | Females | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1960 | 863 | 57.22 | 20.58 | 3.59 | 0.63 |
| 1961 | 193 | 35.10 | 12.85 | 1.36 | 0.56 |
| 1962 | 284 | 66.69 | 16.21 | 4.74 | 1.07 |
| 1963 | 697 | 138.47 | 45.69 | 3.09 | 0.58 |
| 1964 | 300 | 22.41 | 7.92 | 1.62 | 0.53 |
| 1965 | 394 | 65.10 | 14.81 | 3.24 | 0.72 |
| 1966 | 599 | 72.95 | 16.63 | 3.91 | 0.68 |
| 1967 | 601 | 48.54 | 10.00 | 2.19 | 0.47 |
| 1968 | 1,039 | 59.17 | 10.68 | 2.96 | 0.45 |
| 1969 | 611 | 82.53 | 15.10 | 2.88 | 0.51 |
| 1970 | 1,127 | 35.28 | 6.39 | 3.17 | 0.44 |
| 1971 | 592 | 82.53 | 17.89 | 3.55 | 0.59 |
| 1972 | 436 | 65.13 | 16.12 | 3.23 | 0.63 |
| 1973 | 524 | 52.27 | 13.78 | 2.88 | 0.57 |
| 1974 | 405 | 53.83 | 20.24 | 3.45 | 0.73 |
| 1975 | 183 | 47.65 | 16.93 | 2.00 | 0.71 |
| 1976 | 631 | | | 5.49 | 0.86 |
| **Mean** | 557.59 | 61.56 | 2.87 | 3.14 | 0.16 |
| Total banded = 9,479 | | Total recoveries = 713 | | | $\chi^2$ = 52.16, 55 df |
| MLS = 2.06 ± 0.2 | | Model 1 | | | |

Table F10. *Estimates of survival and recovery rates for black ducks banded as adults in Lake Ontario (080).*

| | | Males | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1963 | 159 | 64.78 | 17.50 | 4.40 | 1.63 |
| 1964 | 205 | 53.19 | 13.30 | 8.05 | 1.71 |
| 1965 | 229 | 44.07 | 11.84 | 8.80 | 1.66 |
| 1966 | 146 | 63.91 | 16.15 | 5.50 | 1.47 |
| 1967 | 208 | 72.52 | 18.14 | 5.93 | 1.31 |
| 1968 | 158 | 52.32 | 12.11 | 5.70 | 1.36 |
| 1969 | 340 | 85.60 | 14.14 | 5.08 | 0.98 |
| 1970 | 444 | 106.32 | 31.04 | 8.47 | 1.12 |
| 1971 | 205 | 29.67 | 9.11 | 2.56 | 0.75 |
| 1972 | 291 | 40.91 | 10.34 | 6.46 | 1.18 |
| 1973 | 133 | 78.23 | 19.90 | 8.07 | 1.18 |
| 1974 | 352 | | | 7.41 | 1.24 |
| **Mean** | 239.17 | 62.87 | 3.13 | 6.37 | 0.42 |
| Total banded = 2,870 | | Total recoveries = 445 | | | $\chi^2$ = 42.15, 38 df |
| MLS = 2.15 ± 0.2 | | Model 1 | | | |

Table F11. *Estimates of survival and recovery rates for black ducks banded as adults in Lake Erie (090).*

| Year | Number banded | Survival | S.E. | Recovery | S.E. |
|---|---|---|---|---|---|
| | | Males | | | |
| 1968 | 161 | 63.99* | 3.53* | 4.31 | 0.52* |
| 1969 | 126 | | | | |
| 1970 | 166 | | | | |
| 1971 | 372 | | | | |
| 1972 | 156 | | | | |
| **Mean** | 196.20 | 63.99 | 3.53 | 4.31 | 0.52 |
| Total banded = 981 | | Total recoveries = 113 | | | $\chi^2$ = 16.93, 23 dif |
| MLS = 2.24 ± 0.3 | | Model 3 | | | |

* Average value.

Table F12. *Estimates of survival and recovery rates for black ducks banded as adults in the Tennessee River (110).*

| Year | Number banded | Survival | S.E. | Recovery | S.E. |
|---|---|---|---|---|---|
| | | Males | | | |
| 1963 | 629 | 68.49* | 1.31* | 4.32* | 0.24* |
| 1964 | 772 | | | | |
| 1965 | 282 | | | | |
| 1966 | 457 | | | | |
| 1967 | 502 | | | | |
| 1968 | 227 | | | | |
| 1969 | 245 | | | | |
| 1970 | 529 | | | | |
| 1971 | 507 | | | | |
| **Mean** | 461.11 | 68.49 | 1.31 | 4.32 | 0.24 |
| Total banded = 4,150 | | Total recoveries = 556 | | | $\chi^2$ = 79.84, 72 df |
| MLS = 2.64 ± 0.1 | | Model 3 | | | |

| Year | Number banded | Survival | S.E. | Recovery | S.E. |
|---|---|---|---|---|---|
| | | Females | | | |
| 1963 | 353 | 68.32 | 15.48 | 6.52 | 1.31 |
| 1964 | 537 | 57.00 | 15.19 | 4.86 | 0.84 |
| 1965 | 207 | 100.10 | 30.87 | 3.12 | 0.87 |
| 1966 | 351 | 24.78 | 6.56 | 2.75 | 0.69 |
| 1967 | 394 | 63.97 | 16.37 | 5.92 | 1.03 |
| 1968 | 174 | 68.27 | 21.29 | 4.57 | 1.16 |
| 1969 | 181 | 69.15 | 19.72 | 3.71 | 1.02 |
| 1970 | 366 | 55.41 | 14.42 | 4.97 | 0.97 |
| 1971 | 409 | | | 3.11 | 0.70 |
| **Mean** | 330.22 | 63.38 | 3.70 | 4.39 | 0.35 |
| Total banded = 2,972 | | Total recoveries = 311 | | | $\chi^2$ = 34.09, 28 df |
| MLS = 2.19 ± 0.3 | | Model 1 | | | |

* Average value.

Table F13. *Estimates of survival and recovery rates for black ducks banded as adults in Lake Michigan (120).*

| | | Males | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1967 | 596 | 68.73* | 2.73* | 4.77* | 0.51* |
| 1968 | 267 | | | | |
| 1969 | 138 | | | | |
| **Mean** | 333.67 | 68.73 | 2.73 | 4.77 | 0.51 |
| Total banded = 1,001 | | Total recoveries = 148 | | | $\chi^2$ = 20.47, 20 df |
| MLS = 2.67 ± 0.3 | | Model 3 | | | |

| | | Males | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1972 | 309 | 67.72* | 6.09* | 3.59* | 0.60* |
| 1973 | 257 | | | | |
| 1974 | 119 | | | | |
| **Mean** | 228.33 | 67.72 | 6.09 | 3.59 | 0.60 |
| Total banded = 685 | | Total recoveries = 66 | | | $\chi^2$ = 6.07, 10 df |
| MLS = 2.57 ± 0.6 | | Model 3 | | | |

* Average value.

Table F14. *Estimates of survival and recovery rates for black ducks banded as adults in the Upper Mississippi River (130).*

| Males | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1964 | 287 | 70.90* | 1.35* | 6.22 | 1.42 |
| 1965 | 325 | | | 3.05 | 0.75 |
| 1966 | 845 | | | 3.80 | 0.55 |
| 1967 | 1,537 | | | 5.10 | 0.45 |
| 1968 | 1,101 | | | 3.74 | 0.37 |
| 1969 | 2,042 | | | 4.00 | 0.32 |
| 1970 | 1,747 | | | 5.02 | 0.34 |
| 1971 | 1,089 | | | 3.41 | 0.30 |
| 1972 | 1,295 | | | 3.88 | 0.32 |
| **Mean** | 1,140.89 | 70.90 | 1.35 | 4.25 | 0.22 |
| Total banded = 10,268 | | Total recoveries = 1,316 | | | $\chi^2$ = 61.91, 60 df |
| MLS = 2.91 ± 0.2 | | Model 2 | | | |

| Females | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1964 | 225 | 40.00 | 14.76 | 6.22 | 1.61 |
| 1965 | 206 | 59.25 | 17.75 | 5.34 | 1.43 |
| 1966 | 576 | 38.18 | 8.16 | 5.02 | 0.86 |
| 1967 | 1,095 | 65.95 | 11.44 | 4.69 | 0.60 |
| 1968 | 763 | 51.06 | 8.39 | 3.13 | 0.51 |
| 1969 | 1,478 | 73.91 | 10.44 | 3.54 | 0.42 |
| 1970 | 1,173 | 69.70 | 12.57 | 3.25 | 0.42 |
| 1971 | 818 | 43.93 | 8.12 | 2.63 | 0.43 |
| 1972 | 1,057 | | | 3.80 | 0.49 |
| **Mean** | 821.22 | 55.25 | 2.63 | 4.18 | 0.32 |
| Total banded = 7,391 | | Total recoveries = 624 | | | $\chi^2$ = 39.14, 33 df |
| MLS = 1.69 ± 0.1 | | Model 1 | | | |

* Average value.

# Appendix G. Estimates of Survival and Recovery Rates for Black Ducks Banded as Adults in the Winter Period by Minor Reference Area of Banding.

Estimates of recovery and survival rates and their standard errors were made using the models for birds banded as adults (Program Estimate) as described in Brownie et al. (1978). The "best fit" model is presented. Mean values and their standard errors and an estimate of the mean life span and its standard error also are presented. The number banded by year and in total, and the total recoveries used in the analysis, are given as a guide to the quantity of data in each area. Test statistics for the goodness-of-fit of the models are given. Figure 3 in the text shows the location of each banding reference area.

Table G1. *Estimates of survival and recovery rates for black ducks banded as adults in Maine (021).*

| Year | Number banded | Survival | S.E. | Recovery | S.E. |
|---|---|---|---|---|---|
| Males | | | | | |
| 1960 | 571 | 64.39 | 8.99 | 8.93 | 1.19 |
| 1961 | 403 | 97.15 | 17.85 | 5.04 | 0.85 |
| 1962 | 213 | 88.97 | 24.91 | 6.01 | 1.11 |
| 1963 | 146 | | | 4.60 | 1.17 |
| **Mean** | 333.25 | 83.50 | 7.52 | 6.15 | 0.61 |
| Total banded = 1,333 | | Total recoveries = 273 | | | $\chi^2$ = 6.41, 12 df |
| MLS = 5.55 ± 2.77 | | Model 1 | | | |
| Females | | | | | |
| 1960 | 317 | 38.51 | 10.68 | 6.63 | 1.40 |
| 1961 | 176 | 109.82 | 39.40 | 6.63 | 1.61 |
| 1962 | 141 | | | 4.60 | 1.47 |
| **Mean** | 211.33 | 74.16 | 18.79 | 5.95 | 1.07 |
| Total banded = 634 | | Total recoveries = 80 | | | $\chi^2$ = 3.94, 4 df |
| MLS = 3.35 ± 2.8 | | Model 1 | | | |

Table G2. *Estimates of survival and recovery rates for black ducks banded as adults in New Hampshire (031).*

| | | Males | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1966 | 116 | 60.42* | 11.37* | 12.06 | 3.02 |
| 1967 | 132 | | | 8.42 | 2.06 |
| 1968 | 144 | | | 5.64 | 1.55 |
| **Mean** | 130.67 | 60.42 | 11.37 | 8.71 | 1.34 |
| Total banded = 392 | | Total recoveries = 70 | | | $\chi^2$ = 6.98, 6 df |
| MLS = 1.98 ± 0.7 | | Model 2 | | | |

* Average value.

Table G3. *Estimates of survival and recovery rates for black ducks banded as adults in Massachusetts (032).*

| | | Males | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1939 | 453 | 77.23* | 6.83* | 4.59 | 0.98 |
| 1940 | 642 | | | 3.64 | 0.61 |
| 1941 | 199 | | | 3.22 | 0.65 |
| 1942 | 415 | | | 2.33 | 0.52 |
| **Mean** | 427.25 | 77.23 | 6.83 | 3.44 | 0.38 |
| Total banded = 1,709 | | Total recoveries = 163 | | | $\chi^2$ = 14.01, 13 df |
| MLS = 3.87 ± 1.3 | | Model 2 | | | |

| | | Males | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1969 | 1,514 | 74.30* | 5.68* | 3.76 | 0.49 |
| 1970 | 1,310 | | | 4.15 | 0.43 |
| 1971 | 890 | | | 2.52 | 0.36 |
| **Mean** | 1,238.00 | 74.30 | 5.68 | 3.48 | 0.26 |
| Total banded = 3,714 | | Total recoveries = 390 | | | $\chi^2$ = 19.28, 12 df |
| MLS = 3.37 ± 0.9 | | Model 2 | | | |

* Average value.

Table G4. *Estimates of survival and recovery rates for black ducks banded as adults in Massachusetts (032).*

| | | Males | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1972 | 331 | 58.91* | 5.69* | 2.14 | 0.80 |
| 1973 | 282 | | | 2.92 | 0.78 |
| 1974 | 304 | | | 2.04 | 0.60 |
| 1975 | 706 | | | 4.67 | 0.70 |
| 1976 | 814 | | | 2.86 | 0.48 |
| **Mean** | 487.40 | 58.91 | 5.69 | 2.93 | 0.32 |
| Total banded = 2,437 | | Total recoveries = 139 | | | $\chi^2$ = 11.16, 9 df |
| MLS = 1.89 ± 0.3 | | Model 2 | | | |

| | | Males | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1969 | 1,514 | 94.67 | 14.75 | | |
| 1970 | 1,310 | 78.64 | 14.72 | 2.45 | 0.56 |
| 1971 | 890 | 72.32 | 20.74 | 1.75 | 0.41 |
| 1972 | 331 | 104.43 | 44.84 | 2.04 | 0.61 |
| 1973 | 282 | 40.13 | 19.16 | 1.28 | 0.51 |
| 1974 | 304 | 110.32 | 47.96 | 3.10 | 1.15 |
| 1975 | 706 | 64.62 | 34.77 | 1.03 | 0.40 |
| 1976 | 814 | | | 1.43 | 0.73 |
| **Mean** | 768.88 | 80.73 | 6.99 | 1.87 | 0.25 |
| Total banded = 6,151 | | Total recoveries = 529 | | | $\chi^2$ = 18.77, 19 df |
| MLS = 4.67 ± 1.9 | | Model 0 | | | |

Table G5. *Estimates of survival and recovery rates for black ducks banded as adults in Massachusetts (032).*

| | | Females | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1963 | 233 | 47.80 | 19.62 | 2.15 | 0.95 |
| 1964 | 197 | 25.98 | 11.67 | 5.08 | 1.46 |
| 1965 | 173 | 74.31 | 21.29 | 2.31 | 0.99 |
| 1966 | 856 | 101.60 | 23.03 | 4.09 | 0.64 |
| 1967 | 612 | 27.07 | 6.14 | 2.39 | 0.50 |
| 1968 | 1,164 | 98.40 | 17.63 | 3.43 | 0.48 |
| 1969 | 836 | 47.30 | 8.63 | 2.02 | 0.37 |
| 1970 | 1,107 | 56.80 | 10.63 | 3.60 | 0.46 |
| 1971 | 623 | 83.81 | 28.96 | 2.59 | 0.47 |
| 1972 | 198 | | | 2.21 | 0.72 |
| **Mean** | 609.90 | 62.56 | 4.56 | 2.99 | 0.26 |
| Total banded = 6,099 | | Total recoveries = 458 | | | $\chi^2$ = 32.91, 33 df |
| MLS = 2.13 ± 0.3 | | Model 1 | | | |

Table G6. *Estimates of survival and recovery rates for black ducks banded as adults in New York–Long Island (036).*

| | | Females | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1959 | 500 | 49.56* | 8.17* | 5.01 | 0.98 |
| 1960 | 343 | | | 7.60 | 1.22 |
| 1961 | 268 | | | 2.50 | 0.73 |
| **Mean** | 370.33 | 49.56 | 8.17 | 5.04 | 0.60 |
| Total banded = 1,111 | | Total recoveries = 108 | | | $\chi^2$ = 6.55, 5 df |
| MLS = 1.42 ± 0.3 | | Model 2 | | | |

| | | Females | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1963 | 200 | 57.89* | 3.34* | 5.13 | 1.56 |
| 1964 | 326 | | | 5.43 | 1.09 |
| 1965 | 324 | | | 4.11 | 0.84 |
| 1966 | 361 | | | 3.72 | 0.74 |
| 1967 | 174 | | | 2.24 | 0.64 |
| 1968 | 867 | | | 4.16 | 0.60 |
| 1969 | 389 | | | 3.62 | 0.61 |
| 1970 | 184 | | | 3.82 | 0.76 |
| **Mean** | 353.13 | 57.89 | 3.34 | 4.03 | 0.35 |
| Total banded = 2,825 | | Total recoveries = 248 | | | $\chi^2$ = 22.60, 24 df |
| MLS = 1.83 ± 0.2 | | Model 2 | | | |

* Average value.

Table G7. *Estimates of survival and recovery rates for black ducks banded as adults in New York (042).*

| | | Males | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1957 | 418 | 69.89* | 8.02* | 1.41 | 0.36* |
| 1958 | 104 | | | | |
| 1959 | 171 | | | | |
| **Mean** | 231.00 | 69.89 | 8.02 | 1.41 | 0.36 |
| Total banded = 693 | | Total recoveries = 29 | | | $\chi^2$ = 11.09, 8 df |
| MLS = 2.79 ± 0.9 | | Model 3 | | | |

* Average value.

Table G8. *Estimates of survival and recovery rates for black ducks banded as adults in Virginia (051).*

| Males | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1966 | 224 | 56.57 | 15.30 | 4.91 | 1.44 |
| 1967 | 174 | 128.72 | 28.91 | 3.28 | 1.09 |
| 1968 | 602 | 61.00 | 14.46 | 3.70 | 0.66 |
| 1969 | 269 | 52.51 | 12.15 | 2.44 | 0.64 |
| 1970 | 428 | 59.63 | 12.42 | 3.20 | 0.65 |
| 1971 | 189 | 111.74 | 33.20 | 6.72 | 1.31 |
| 1972 | 185 | | | 3.48 | 0.94 |
| **Mean** | 295.86 | 78.36 | 6.11 | 3.96 | 0.42 |
| Total banded = 2,071 | | Total recoveries = 251 | | | $\chi^2$ = 31.00, 32 df |
| MLS = 4.10 ± 1.3 | | Model 1 | | | |

| Females | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1966 | 179 | 66.02* | 3.40* | 2.73* | 0.34* |
| 1967 | 146 | | | | |
| 1968 | 437 | | | | |
| 1969 | 173 | | | | |
| 1970 | 339 | | | | |
| 1971 | 158 | | | | |
| **Mean** | 238.67 | 66.02 | 3.40 | 2.73 | 0.34 |
| Total banded = 1,432 | | Total recoveries = 111 | | | $\chi^2$ = 38.07, 29 df |
| MLS = 2.41 ± 0.3 | | Model 3 | | | |

* Average value.

Table G9. *Estimates of survival and recovery rates for black ducks banded as adults in North Carolina (052).*

| Year | Number banded | Survival | S.E. | Recovery | S.E. |
|---|---|---|---|---|---|
| | | Males | | | |
| 1962 | 176 | 69.51* | 2.42* | 2.25 | 1.12 |
| 1963 | 141 | | | 2.29 | 0.92 |
| 1964 | 424 | | | 3.19 | 0.72 |
| 1965 | 418 | | | 2.51 | 0.55 |
| 1966 | 231 | | | 3.05 | 0.62 |
| 1967 | 197 | | | 2.21 | 0.55 |
| 1968 | 246 | | | 2.69 | 0.61 |
| 1969 | 401 | | | 3.18 | 0.60 |
| 1970 | 193 | | | 1.89 | 0.49 |
| 1971 | 381 | | | 4.35 | 0.71 |
| 1972 | 197 | | | 2.64 | 0.58 |
| **Mean** | 273.18 | 69.51 | 2.42 | 2.75 | 0.24 |
| Total banded = 3,005 | | Total recoveries = 261 | | | $\chi^2$ = 51.62, 54 df |
| MLS = 2.75 ± 0.3 | | Model 2 | | | |

| Year | Number banded | Survival | S.E. | Recovery | S.E. |
|---|---|---|---|---|---|
| | | Females | | | |
| 1963 | 140 | 53.85* | 3.42* | 3.46 | 1.54 |
| 1964 | 349 | | | 4.00 | 0.95 |
| 1965 | 263 | | | 2.06 | 0.65 |
| 1966 | 139 | | | 3.23 | 0.91 |
| 1967 | 143 | | | 2.49 | 0.85 |
| 1968 | 175 | | | 1.87 | 0.72 |
| 1969 | 361 | | | 3.95 | 0.85 |
| 1970 | 173 | | | 5.34 | 1.11 |
| 1971 | 365 | | | 3.55 | 0.77 |
| 1972 | 157 | | | 3.45 | 0.87 |
| **Mean** | 226.50 | 53.85 | 3.42 | 3.34 | 0.34 |
| Total banded = 2,265 | | Total recoveries = 166 | | | $\chi^2$ = 33.77, 24 df |
| MLS = 1.62 ± 0.2 | | Model 2 | | | |

* Average value.

Table G10. *Estimates of survival and recovery rates for black ducks banded as adults in Delaware (053).*

| | | Males | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1963 | 355 | 68.46* | 3.72* | 3.58* | 0.52* |
| 1964 | 219 | | | | |
| 1965 | 171 | | | | |
| **Mean** | 248.33 | 68.46 | 3.72 | 3.58 | 0.52 |
| Total banded = 745 | | Total recoveries = 82 | | | $\chi^2$ = 10.48, 16 df |
| MLS = 2.64 ± 0.4 | | Model 3 | | | |

* Average value.

Table G11. *Estimates of survival and recovery rates for black ducks banded as adults in Maryland (055).*

| | | Males | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1961 | 406 | 71.29* | 10.49* | 4.20 | 1.00 |
| 1962 | 379 | | | 4.48 | 0.86 |
| 1963 | 242 | | | 3.34 | 0.82 |
| **Mean** | 342.33 | 71.29 | 10.49 | 4.01 | 0.54 |
| Total banded = 1,027 | | Total recoveries = 107 | | | $\chi^2$ = 12.67, 12 df |
| MLS = 2.96 ± 1.3 | | Model 2 | | | |

| | | Males | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1967 | 302 | 68.97* | 3.02* | 5.29 | 1.29 |
| 1968 | 252 | | | 2.78 | 0.77 |
| 1969 | 460 | | | 5.67 | 0.85 |
| 1970 | 226 | | | 3.68 | 0.71 |
| 1971 | 486 | | | 2.78 | 0.54 |
| 1972 | 457 | | | 3.56 | 0.58 |
| 1973 | 437 | | | 3.73 | 0.59 |
| **Mean** | 374.29 | 68.97 | 3.02 | 3.93 | 0.32 |
| Total banded = 2,620 | | Total recoveries = 294 | | | $\chi^2$ = 40.35, 33 df |
| MLS = 2.69 ± 0.3 | | Model 2 | | | |

* Average value.

Table G12. *Estimates of survival and recovery rates for black ducks banded as adults in Maryland (055).*

| | | Females | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1957 | 153 | 59.32* | 3.03* | 3.54* | 0.39* |
| 1958 | 284 | | | | |
| 1959 | 150 | | | | |
| 1960 | 206 | | | | |
| 1961 | 295 | | | | |
| 1962 | 253 | | | | |
| 1963 | 167 | | | | |
| **Mean** | 215.43 | 59.32 | 3.03 | 3.54 | 0.39 |
| Total banded = 1,508 | | Total recoveries = 130 | | | $\chi^2$ = 33.40, 30 df |
| MLS = 1.91 ± 0.2 | | Model 3 | | | |

| | | Females | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1971 | 296 | 62.74* | 5.35* | 2.82* | 0.45* |
| 1972 | 329 | | | | |
| 1973 | 336 | | | | |
| **Mean** | 320.33 | 62.74 | 5.35 | 2.82 | 0.45 |
| Total banded = 961 | | Total recoveries = 68 | | | $\chi^2$ = 11.89, 12 df |
| MLS = 2.15 ± 0.4 | | Model 3 | | | |

* Average value.

Table G13. *Estimates of survival and recovery rates for black ducks banded as adults in New Jersey (063).*

| Males | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1952 | 167 | 63.49* | 3.43* | 5.10* | 0.65* |
| 1953 | 180 | | | | |
| 1954 | 178 | | | | |
| 1955 | 198 | | | | |
| **Mean** | 180.75 | 63.49 | 3.43 | 5.10 | 0.65 |
| Total banded = 723 | | Total recoveries = 99 | | | $\chi^2$ = 20.27, 22 df |
| MLS = 2.19 ± 0.3 | | Model 3 | | | |

| Males | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1959 | 224 | 73.45* | 13.21 | 6.21 | 1.61 |
| 1960 | 995 | | | 4.66 | 0.63 |
| 1961 | 167 | | | 2.16 | 0.59 |
| **Mean** | 462.00 | 73.45 | 13.21 | 4.34 | 0.62 |
| Total banded = 1,386 | | Total recoveries = 149 | | | $\chi^2$ = 6.59, 12 df |
| MLS = 3.24 ± 1.9 | | Model 2 | | | |

* Average value.

Table G14. *Estimates of survival and recovery rates for black ducks banded as adults in New Jersey (063).*

| Males | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1963 | 489 | 69.18 | *1.21* | 5.02 | 0.99 |
| 1964 | 218 | | | 3.20 | 0.75 |
| 1965 | 244 | | | 2.68 | 0.65 |
| 1966 | 696 | | | 4.22 | 0.60 |
| 1967 | 816 | | | 3.85 | 0.49 |
| 1968 | 1,309 | | | 5.10 | 0.46 |
| 1969 | 722 | | | 3.70 | 0.40 |
| 1970 | 1,320 | | | 3.76 | 0.36 |
| 1971 | 541 | | | 3.04 | 0.35 |
| 1972 | 594 | | | 4.30 | 0.45 |
| 1973 | 580 | | | 4.24 | 0.46 |
| 1974 | 526 | | | 2.99 | 0.40 |
| 1975 | 217 | | | 3.21 | 0.47 |
| 1976 | 606 | | | 4.46 | 0.54 |
| **Mean** | 634.14 | 69.18 | 1.21 | 3.84 | 0.17 |
| Total banded = 8,878 | | Total recoveries = 986 | | | $\chi^2$ = 84.12, 76 df |
| MLS = 2.71 ± 0.1 | | Model 2 | | | |

* Average value.

Table G15. *Estimates of survival and recovery rates for black ducks banded as adults in New Jersey (063).*

| | | Females | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1965 | 191 | 61.00* | 1.90* | 3.76 | 1.38 |
| 1966 | 495 | | | 4.09 | 0.80 |
| 1967 | 415 | | | 3.03 | 0.62 |
| 1968 | 783 | | | 2.93 | 0.48 |
| 1969 | 545 | | | 2.90 | 0.47 |
| 1970 | 986 | | | 3.33 | 0.44 |
| 1971 | 558 | | | 2.92 | 0.43 |
| 1972 | 427 | | | 3.22 | 0.50 |
| 1973 | 517 | | | 3.02 | 0.49 |
| 1974 | 404 | | | 3.43 | 0.55 |
| 1975 | 169 | | | 1.82 | 0.46 |
| 1976 | 540 | | | 4.61 | 0.68 |
| **Mean** | 502.50 | 61.00 | 1.90 | 3.25 | 0.21 |
| Total banded = 6,030 | | Total recoveries = 455 | | | $\chi^2$ = 42.47, 46 df |
| MLS = 2.02 ± 0.1 | | Model 2 | | | |

* Average value.

Table G16. *Estimates of survival and recovery rates for black ducks banded as adults in Virginia (064).*

| | | Males | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1965 | 173 | 77.06* | 4.62* | 1.98* | 0.40* |
| 1966 | 111 | | | | |
| 1967 | 149 | | | | |
| 1968 | 205 | | | | |
| **Mean** | 159.50 | 77.06 | 4.62 | 1.98 | 0.40 |
| Total banded = 638 | | Total recoveries = 50 | | | $\chi^2$ = 23.87, 22 df |
| MLS = 3.84 ± 0.9 | | Model 3 | | | |

* Average value.

Table G17. *Estimates of survival and recovery rates for black ducks banded as adults in New York (081).*

| Males | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1956 | 159 | 65.02* | 9.48* | 6.94 | 2.01 |
| 1957 | 144 | | | 10.48 | 2.08 |
| 1958 | 123 | | | 6.70 | 1.67 |
| **Mean** | 142.00 | 65.02 | 9.48 | 8.04 | 1.15 |

Total banded = 426 Total recoveries = 82 $\chi^2$ = 15.85, 10 df

MLS = 2.32 ± 0.8 Model 2

| Males | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1964 | 205 | 54.66 | 14.43 | 7.81 | 1.87 |
| 1965 | 229 | 40.17 | 11.28 | 9.32 | 1.76 |
| 1966 | 137 | 55.51 | 15.30 | 6.08 | 1.64 |
| 1967 | 130 | 84.35 | 22.66 | 6.21 | 1.63 |
| 1968 | 158 | 56.60 | 13.02 | 4.87 | 1.27 |
| 1969 | 340 | 86.87 | 14.32 | 4.87 | 0.96 |
| 1970 | 444 | 105.05 | 30.69 | 8.53 | 1.13 |
| 1971 | 204 | 30.16 | 9.26 | 2.52 | 0.74 |
| 1972 | 291 | 40.19 | 10.34 | 6.46 | 1.18 |
| 1973 | 133 | 78.23 | 19.90 | 8.07 | 1.81 |
| 1974 | 352 | | | 7.41 | 1.24 |
| **Mean** | 238.46 | 63.25 | 3.32 | 6.47 | 0.46 |

Total banded = 2,623 Total recoveries = 408 $\chi^2$ = 33.94, 35 df

MLS = 2.18 ± 0.3 Model 1

Table G18. *Estimates of survival and recovery rates for black ducks banded as adults in Tennessee (113).*

| Males | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1963 | 625 | 57.60 | 8.82 | 3.36 | 0.72 |
| 1964 | 764 | 67.47 | 11.70 | 4.97 | 0.69 |
| 1965 | 276 | 58.10 | 11.39 | 4.38 | 0.83 |
| 1966 | 283 | 129.01 | 27.41 | 5.87 | 0.99 |
| 1967 | 360 | 48.83 | 12.45 | 3.66 | 0.71 |
| 1968 | 227 | 55.73 | 13.95 | 3.26 | 0.77 |
| 1969 | 237 | 65.85 | 13.48 | 4.78 | 0.98 |
| 1970 | 481 | 60.06 | 10.06 | 5.17 | 0.81 |
| 1971 | 477 | | | 5.27 | 0.80 |
| **Mean** | 414.44 | 67.83 | 2.72 | 4.52 | 0.29 |
| Total banded = 3,730 | | Total recoveries = 524 | | | $\chi^2$ = 56.50, 46 df |
| MLS = 2.58 | | Model 1 | | | |

| Females | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1963 | 351 | 59.99* | 2.55* | 6.59 | 1.32 |
| 1964 | 530 | | | 5.11 | 0.82 |
| 1965 | 200 | | | 3.24 | 0.71 |
| 1966 | 159 | | | 4.70 | 0.96 |
| 1967 | 282 | | | 5.49 | 0.98 |
| 1968 | 174 | | | 4.69 | 0.97 |
| 1969 | 164 | | | 4.33 | 0.98 |
| 1970 | 315 | | | 5.58 | 0.98 |
| 1971 | 379 | | | 3.36 | 0.68 |
| **Mean** | 283.78 | 59.99 | 2.55 | 4.79 | 0.36 |
| Total banded = 2,554 | | Total recoveries = 287 | | | $\chi^2$ = 37.53, 33 df |
| MLS = 1.96 | | Model 2 | | | |

* Average value.

Table G19. *Estimates of survival and recovery rates for black ducks banded as adults in Michigan (123).*

| Males | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1967 | 165 | 68.72* | 3.35* | 3.89* | 0.47* |
| 1968 | 265 | | | | |
| 1969 | 138 | | | | |
| 1970 | 218 | | | | |
| 1971 | 257 | | | | |
| **Mean** | 208.60 | 68.72 | 3.35 | 3.89 | 0.47 |
| Total banded = 1,043 | | Total recoveries = 122 | | | $\chi^2$ = 24.12, 27 df |
| MLS = 2.67 ± 0.4 | | Model 3 | | | |

* Average value.

Table G20. *Estimates of survival and recovery rates for black ducks banded as adults in Illinois (131).*

| Males | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1969 | 1,140 | 67.24* | 3.86* | 3.69 | 0.56 |
| 1970 | 583 | | | 5.71 | 0.67 |
| 1971 | 432 | | | 4.31 | 0.62 |
| 1972 | 576 | | | 4.00 | 0.58 |
| **Mean** | 682.75 | 67.24 | 3.86 | 4.43 | 0.34 |
| Total banded = 2,731 | | Total recoveries = 331 | | | $\chi^2$ = 14.07, 16 df |
| MLS = 2.52 ± 0.4 | | Model 2 | | | |

| Females | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1969 | 896 | 59.50* | 2.99* | 3.16* | 0.32* |
| 1970 | 370 | | | | |
| 1971 | 313 | | | | |
| 1972 | 505 | | | | |
| **Mean** | 521.00 | 59.50 | 2.99 | 3.16 | 0.32 |
| Total banded = 2,084 | | Total recoveries = 159 | | | $\chi^2$ = 24.83, 20 df |
| MLS = 1.93 ± 0.2 | | Model 3 | | | |

* Average value.

Table G21. *Estimates of survival and recovery rates for black ducks banded as adults in Tennessee (133).*

| Males | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1964 | 147 | 72.77* | 1.78* | 3.25 | 1.46 |
| 1965 | 277 | | | 3.39 | 0.92 |
| 1966 | 714 | | | 3.34 | 0.57 |
| 1967 | 980 | | | 4.88 | 0.53 |
| 1968 | 880 | | | 3.53 | 0.41 |
| 1969 | 900 | | | 3.96 | 0.42 |
| 1970 | 989 | | | 4.34 | 0.42 |
| 1971 | 560 | | | 2.92 | 0.36 |
| 1972 | 542 | | | 3.35 | 0.41 |
| **Mean** | 665.44 | 72.77 | 1.78 | 3.66 | 0.24 |
| Total banded = 5,989 | | Total recoveries = 742 | | | $\chi^2$ = 57.30, 58 df |
| MLS = 3.15 ± 0.2 | | Model 2 | | | |

| Females | | | | | |
|---|---|---|---|---|---|
| Year | Number banded | Survival | S.E. | Recovery | S.E. |
| 1965 | 162 | 59.02* | 2.60* | 6.72 | 1.96 |
| 1966 | 481 | | | 4.62 | 0.88 |
| 1967 | 738 | | | 4.27 | 0.62 |
| 1968 | 631 | | | 3.16 | 0.50 |
| 1969 | 580 | | | 3.71 | 0.55 |
| 1970 | 709 | | | 3.70 | 0.52 |
| 1971 | 442 | | | 3.24 | 0.53 |
| 1972 | 469 | | | 4.07 | 0.62 |
| **Mean** | 526.50 | 59.02 | 2.60 | 4.19 | 0.33 |
| Total banded = 4,212 | | Total recoveries = 366 | | | $\chi^2$ = 23.79, 31 df |
| MLS = 1.90 ± 0.2 | | Model 2 | | | |

* Average value.

# Appendix H. Results of Testing the Hypothesis That Black Duck Recovery Rates or Survival Rates Are the Same in Various Reference Areas of Banding (Preseason Bandings—Corresponding Years).

Table H1. *Results of testing the hypothesis that male black duck recovery rates are the same in various states/provinces (preseason bandings—corresponding years).*

| State/Province compared | vs. | Year comparisons | Mean recovery rate comparisons | vs. | Difference | Test statistic $z$ value |
|---|---|---|---|---|---|---|
| **Adult** | | | | | | |
| MA | NY | 1968–1971 | 4.0 | 7.6 | −3.6 | −3.197*** |
| MI | NY | 1967–1971 | 6.8 | 6.8 | 0.0 | 0.050 |
| MI | ON | 1967–1973 | 6.8 | 6.3 | 0.5 | 0.728 |
| NY | ON | 1964–1967 | 7.0 | 6.6 | 0.4 | −0.685 |
| MA | QU | 1968–1971 | 4.0 | 5.5 | −1.5 | −1.966** |
| MI | QU | 1967–1973 | 6.8 | 5.5 | 1.3 | 1.802* |
| ON | QU | 1964–1975 | 6.2 | 5.5 | 0.7 | 1.068 |
| **Young** | | | | | | |
| MA | NY | 1968–1971 | 9.6 | 13.3 | −3.7 | −3.100*** |
| MI | NY | 1967–1971 | 7.1 | 13.0 | −5.9 | −5.740*** |
| MI | ON | 1967–1973 | 7.1 | 10.9 | −3.8 | −4.908*** |
| NY | ON | 1964–1967 | 13.0 | 11.7 | 1.3 | 1.936* |
| MA | QU | 1968–1971 | 9.6 | 13.1 | −3.5 | −3.251*** |
| MI | QU | 1967–1973 | 7.1 | 11.9 | −4.8 | −5.484*** |
| ON | QU | 1964–1975 | 11.3 | 11.4 | −0.1 | −0.169 |

*$\alpha < 0.1$; **$\alpha < 0.05$; ***$\alpha < 0.01$.

Table H2. *Results of testing the hypothesis that female black duck recovery rates are the same in various states/provinces (preseason bandings—corresponding years).*

| State/Province compared | vs. | Year comparisons | Mean recovery rate comparisons | vs. | Difference | Test statistic $z$ value |
|---|---|---|---|---|---|---|
| **Adult** | | | | | | |
| ME | NY | 1961–1966 | 5.8 | 5.0 | 0.8 | 0.792 |
| MA | QU | 1968–1971 | 5.0 | 5.5 | 0.5 | −0.518 |
| ON | QU | 1968–1971 | 5.0 | 5.5 | 0.5 | −0.609 |
| **Young** | | | | | | |
| ME | NY | 1961–1966 | 11.8 | 11.3 | 0.5 | 0.716 |
| MA | QU | 1968–1971 | 8.4 | 11.3 | −2.9 | −2.627*** |
| ON | QU | 1968–1971 | 10.1 | 11.3 | −1.2 | −1.303 |

***$\alpha < 0.1$.

Table H3. *Results of testing the hypothesis that adult black duck recovery rates are the same in various major reference areas (preseason bandings—corresponding years).*

| Reference area comparisons | vs. | Year comparisons vs. | Mean recovery rate comparisons | vs. | Difference | Test statistic $z$ value |
|---|---|---|---|---|---|---|
| **Male** | | | | | | |
| Lab & E Que (02) | E Lake Ont (12) | 1962–1964 | 5.2 | 6.8 | –1.7 | –1.641* |
| S Que (04) | E Lake Ont (12) | 1969–1975 | 6.4 | 7.0 | –0.6 | –1.016 |
| | W Lake Ont (13) | 1968–1972 | | 6.5 | –0.1 | –0.155 |
| E Lake Ont (12) | W Lake Ont (13) | 1965–1972 | 7.0 | 6.5 | 0.4 | 0.887 |
| | Up Gt Lakes (15) | 1964–1968 | | 6.5 | 0.4 | 0.587 |
| W Lake Erie (16)† | E Lake Ont (12) | 1968–1972 | 7.5 | 7.0 | 0.4 | 0.617 |
| | W Lake Ont (13) | 1968–1972 | | 6.5 | 1.0 | 1.368 |
| **Female** | | | | | | |
| Maritimes (01) | S Que (04) | 1970–1971 | 5.8 | 4.7 | 1.1 | 0.720 |
| | E Lake Ont (12) | 1970–1971 | | 6.1 | –0.3 | –0.133 |
| S Que (04) | E Lake Ont (12) | 1968–1971 | 5.9 | 6.0 | –0.1 | –0.099 |
| | W Lake Ont (13) | 1968 | 8.9 | 6.1 | 2.9 | 1.180 |
| | Up Gt Lakes (15) | 1968 | | 6.4 | 2.5 | 1.143 |
| E Lake Ont (12) | W Lake Ont (13) | 1965–1968 | 5.5 | 5.9 | –0.4 | –0.336 |
| | Up Gt Lakes (15) | 1964–1968 | 5.1 | 6.4 | –1.3 | –1.112 |

*$\alpha<0.1$.
†Adult and young banding data pooled.

Table H4. *Results of testing the hypothesis that young black duck recovery rates are the same in various major reference areas (preseason bandings—corresponding years).*

| Reference area comparisons | vs. | Year comparisons vs. | Mean recovery rate comparisons | vs. | Difference | Test statistic $z$ value |
|---|---|---|---|---|---|---|
| **Male** | | | | | | |
| Lab & E Que (02) | E Lake Ont (12) | 1962–1964 | 6.1 | 12.2 | –6.1 | –3.681*** |
| S Que (04) | E Lake Ont (12) | 1969–1975 | 13.3 | 11.7 | 1.6 | 1.711* |
| | W Lake Ont (13) | 1968–1972 | | 12.2 | 1.1 | 1.170 |
| E Lake Ont (12) | W Lake Ont (13) | 1965–1972 | 12.1 | 12.3 | –0.1 | –0.218 |
| | Up Gt Lakes (15) | 1964–1968 | 12.4 | 9.6 | 2.8 | 2.902*** |
| **Female** | | | | | | |
| Maritimes (01) | S Que (04) | 1970–1971 | 11.4 | 11.2 | 0.2 | 0.131 |
| | E Lake Ont (12) | 1970–1971 | | 13.7 | –2.3 | –1.832 |
| S Que (04) | E Lake Ont (12) | 1968–1971 | 12.4 | 12.5 | –0.1 | –0.080 |
| | W Lake Ont (13) | 1968 | 9.1 | 10.4 | –1.4 | –0.556 |
| | Up Gt Lakes (15) | 1968 | | 4.7 | 4.4 | 1.877* |
| E Lake Ont (12) | W Lake Ont (13) | 1965–1968 | 12.2 | 12.1 | 0.1 | 0.164 |
| | Up Gt Lakes (15) | 1964–1968 | 12.5 | 8.5 | 4.0 | 3.952*** |

*$\alpha < 0.1$; ***$\alpha < 0.01$.

Table H5. *Results of testing the hypothesis that adult black duck recovery rates are the same in various minor reference areas (preseason bandings—corresponding years).*

| Reference area comparisons vs. | | Year comparisons vs. | Mean recovery rate comparisons vs. | | Difference | Test statistic $z$ value |
|---|---|---|---|---|---|---|
| **Male** | | | | | | |
| Que (041) | NY (122) | 1968–1970 | 6.9 | 8.0 | –1.1 | –0.746 |
| | Ill (131) | 1968–1972 | 6.3 | 6.8 | –0.5 | –0.634 |
| | Ont (151) | 1968 | 5.8 | 4.0 | 1.8 | 0.963 |
| NY (122) | Ont (131) | 1965–1972 | 7.7 | 6.8 | 0.9 | 1.041 |
| | Ont (151) | 1964–1968 | 6.2 | 5.9 | 1.5 | 2.188** |
| Ont (131) | Ont (151) | 1965–1968 | 6.8 | 6.0 | 0.8 | 1.011 |
| **Female** | | | | | | |
| Que (041) | Mass (081) | 1969–1971 | 6.9 | 4.4 | 2.5 | 2.587*** |

**$\alpha < 0.05$; ***$\alpha < 0.01$.

Table H6. *Results of testing the hypothesis that young black duck recovery rates are the same in various minor reference areas (preseason bandings—corresponding years).*

| Reference area comparisons vs. | | Year comparisons vs. | Mean recovery rate comparisons vs. | | Difference | Test statistic $z$ value |
|---|---|---|---|---|---|---|
| **Male** | | | | | | |
| Que (041) | NY (122) | 1968–1970 | 15.2 | 12.5 | 2.7 | 1.876* |
| | Ill (131) | 1968–1972 | 13.3 | 11.0 | 2.3 | 2.677*** |
| | Ont (151) | 1968 | 13.8 | 10.5 | 3.4 | 1.780* |
| NY (122) | Ont (131) | 1965–1970 | 12.2 | 11.0 | 1.2 | 1.421 |
| | Ont (151) | 1964–1968 | 11.7 | 9.4 | 2.4 | 1.799* |
| **Female** | | | | | | |
| Que (041) | Mass (081) | 1969–1971 | 13.5 | 7.4 | 6.1 | 4.347*** |

*$\alpha < 0.1$; ***$\alpha < 0.01$.

Table H7. *Results of testing the hypothesis that male black duck survival rates are the same in various states/ provinces (preseason bandings—corresponding years).*

| State/Province compared vs. | | Year comparisons | Mean survival rate comparisons vs. | | Difference | Test statistic $z$ value |
|---|---|---|---|---|---|---|
| **Adult** | | | | | | |
| MA | NY | 1968–1971 | 74.5 | 66.8 | 7.8 | 0.555 |
| MI | NY | 1967–1971 | 63.4 | 62.9 | 0.5 | 0.043 |
| MI | ON | 1967–1973 | 63.4 | 61.5 | 1.9 | 0.706 |
| NY | ON | 1964–1967 | 60.0 | 61.5 | −1.5 | −0.210 |
| MA | QU | 1968–1971 | 74.5 | 64.8 | 9.7 | 1.289 |
| MI | QU | 1967–1973 | 63.4 | 64.8 | −1.5 | −0.513 |
| ON | QU | 1964–1975 | 61.5 | 64.8 | −3.3 | −1.724* |
| **Young** | | | | | | |
| MA | NY | 1968–1971 | 58.2 | 45.9 | 12.3 | 0.891 |
| MI | NY | 1967–1972 | 43.0 | 45.2 | −2.2 | −0.261 |
| MI | ON | 1967–1973 | 43.0 | 47.3 | −4.3 | −0.736 |
| NY | ON | 1964–1967 | 46.9 | 47.3 | −0.4 | −0.083 |
| MA | QU | 1968–1971 | 58.2 | 38.8 | 19.4 | 1.653* |
| MI | QU | 1967–1973 | 43.0 | 38.8 | 4.2 | 0.710 |
| ON | QU | 1964–1975 | 47.3 | 38.8 | 8.6 | 2.196** |

*$\alpha < 0.1$; **$\alpha < 0.05$.

Table H8. *Results of testing the hypothesis that female black duck survival rates are the same in various states/ provinces (preseason bandings—corresponding years).*

| State/Province compared vs. | | Year comparisons | Mean survival rate comparisons vs. | | Difference | Test statistic $z$ value |
|---|---|---|---|---|---|---|
| **Adult** | | | | | | |
| ME | NY | 1961–1966 | 50.7 | 52.9 | −2.2 | −0.216 |
| MA | QU | 1968–1971 | 49.8 | 60.3 | −10.5 | −0.714 |
| ON | QU | 1968–1971 | 61.4 | 60.3 | 1.1 | 0.106 |
| **Young** | | | | | | |
| ME | NY | 1961–1966 | 45.2 | 45.1 | 0.1 | 0.014 |
| MA | QU | 1968–1971 | 41.4 | 41.5 | −0.1 | −0.002 |
| ON | QU | 1968–1971 | 43.9 | 41.5 | 2.4 | 0.277 |

Table H9. *Results of testing the hypothesis that adult black duck survival rates are the same in various major reference areas (preseason bandings—corresponding years).*

| Reference area comparisons | vs. | Year comparisons vs. | Mean survival rate comparisons | vs. | Difference | Test statistic z value |
|---|---|---|---|---|---|---|
| **Male** | | | | | | |
| Lab & E Que (02) | E Lake Ont (12) | 1962–1964 | 69.4 | 58.1 | 11.3 | 2.227** |
| S Que (04) | E Lake Ont (12) | 1969–1975 | 66.0 | 58.1 | 8.0 | 3.022*** |
| | W Lake Ont (13) | 1968–1972 | | 62.3 | 3.8 | 1.216 |
| E Lake Ont (12) | W Lake Ont (13) | 1965–1972 | 58.1 | 62.3 | –4.2 | –1.766* |
| | Up Gt Lakes (15) | 1964–1968 | | 63.9 | –5.8 | –1.648* |
| W Lake Erie (16)† | E Lake Ont (12) | 1968–1972 | 57.5 | 58.1 | –0.6 | –0.177 |
| | W Lake Ont (13) | 1968–1972 | | 62.3 | –4.8 | –1.264 |
| **Female** | | | | | | |
| Maritimes (01) | S Que (04) | 1970–1971 | 43.8 | 60.0 | –16.2 | –2.502* |
| | E Lake Ont (12) | 1970–1971 | | 26.5 | 17.4 | 1.306 |
| S Que (04) | E Lake Ont (12) | 1968–1971 | 60.0 | 50.5 | 9.5 | 0.879 |
| | W Lake Ont (13) | 1968 | | 48.3 | 11.8 | 1.664* |
| | Up Gt Lakes (15) | 1968 | | 49.9 | 10.2 | 1.647* |
| E Lake Ont (12) | W Lake Ont (13) | 1965–1968 | 49.4 | 48.3 | 1.1 | 0.121 |
| | Up Gt Lakes (15) | 1964–1968 | 47.5 | 49.9 | –2.4 | –0.343 |

*$\alpha < 0.1$; **$\alpha < 0.05$; ***$\alpha < 0.01$.
†Adult and young banding data pooled.

Table H10. *Results of testing the hypothesis that young black duck survival rates are the same in various major reference areas (preseason bandings—corresponding years).*

| Reference area comparisons | vs. | Year comparisons vs. | Mean survival rate comparisons | vs. | Difference | Test statistic z value |
|---|---|---|---|---|---|---|
| **Male** | | | | | | |
| Lab & E Que (02) | E Lake Ont (12) | 1962–1964 | 41.4 | 43.6 | –2.3 | –0.194 |
| S Que (04) | E Lake Ont (12) | 1969–1975 | 35.6 | 43.6 | –8.1 | –1.851* |
| | W Lake Ont (13) | 1968–1972 | | 44.5 | –8.9 | –1.735* |
| E Lake Ont (12) | W Lake Ont (13) | 1965–1972 | 43.6 | 44.5 | –0.9 | –0.189 |
| | Up Gt Lakes (15) | 1964–1968 | | 50.3 | –6.7 | –1.046 |
| **Female** | | | | | | |
| Maritimes (01) | S Que (04) | 1970–1971 | 42.2 | 40.3 | 1.9 | 0.094 |
| | E Lake Ont (12) | 1970–1971 | | 30.1 | 12.2 | 0.684 |
| S Que (04) | E Lake Ont (12) | 1968–1971 | 41.6 | 45.8 | –4.2 | |
| | W Lake Ont (13) | 1968 | 50.0 | 58.9 | –8.9 | –0.501 |
| | Up Gt Lakes (15) | 1968 | | 57.5 | –7.5 | –0.447 |
| E Lake Ont (12) | W Lake Ont (13) | 1965–1968 | 39.6 | 58.9 | –19.2 | –1.560 |

*$\alpha$<0.1.

Table H11. *Results of testing the hypothesis that adult black duck survival rates are the same in various minor reference areas (preseason bandings—corresponding years).*

| Reference area comparisons | vs. | Year comparisons vs. | Mean survival rate comparisons | vs. | Difference | Test statistic $z$ value |
|---|---|---|---|---|---|---|
| **Male** | | | | | | |
| Que (041) | NY (122) | 1968–1970 | 67.4 | 58.1 | 9.4 | –0.763 |
| | Ill (131) | 1968–1972 | | 59.3 | 8.1 | 2.765*** |
| | Ont (151) | 1968 | | 69.2 | –1.7 | –0.357 |
| NY (122) | Ont (131) | 1965–1972 | 57.9 | 59.3 | –1.4 | –0.513 |
| | Ont (151) | 1964–1968 | 56.8 | 69.2 | –12.4 | –2.763*** |
| Ont (131) | Ont (151) | 1965–1968 | 59.3 | 69.2 | –9.9 | –2.134** |
| **Female** | | | | | | |
| Que (041) | Mass (081) | 1969–1971 | 67.4 | 52.4 | 15.0 | 0.885 |

**$\alpha < 0.05$; ***$\alpha < 0.01$.

Table H12. *Results of testing the hypothesis that young black duck survival rates are the same in various minor reference areas (preseason bandings—corresponding years).*

| Reference area comparisons | vs. | Year comparisons vs. | Mean survival rate comparisons | vs. | Difference | Test statistic $z$ value |
|---|---|---|---|---|---|---|
| **Male** | | | | | | |
| Que (041) | NY (122) | 1968–1970 | 37.0 | 34.5 | 2.4 | 0.281 |
| | Ill (131) | 1968–1972 | 35.3 | 41.4 | –6.1 | –0.743 |
| | Ont (151) | 1968 | 37.0 | 43.1 | –6.1 | –0.976 |
| NY (122) | Ont (131) | 1965–1970 | 40.1 | 41.4 | 0.5 | –0.135 |
| | Ont (151) | 1964–1968 | 40.1 | 75.6 | –34.8 | –3.110*** |
| Ont (131) | Ont (151) | 1965–1968 | 41.4 | 75.6 | –34.3 | –2.875*** |
| **Female** | | | | | | |
| Que (041) | Mass (081) | 1969–1971 | 43.2 | 35.2 | 8.0 | 0.626 |

***$\alpha < 0.01$.

# Appendix I. Results of Testing the Hypothesis That Black Duck Recovery Rates or Survival Rates Are the Same in Various Reference Areas of Banding (Preseason Bandings—Noncorresponding Years).

Table I1. *Results of testing the hyopthesis that adult male black duck recovery rates are the same in various states/provinces (preseason bandings).*

| Reference areas vs. | | Year comparisons vs. | | Mean recovery rate comparisons vs. | | Difference | Test statistic $z$ value |
|---|---|---|---|---|---|---|---|
| NY | ON | 1950–53 | 1964–77 | 6.4 | 6.1 | 0.3 | 0.452 |
| | QU | | 1963–75 | | 5.6 | 0.8 | 1.070 |
| ON | QU | 1964–77 | 1963–75 | 6.1 | 5.6 | 0.5 | 1.325 |
| NY | ON | 1960–67 | 1964–77 | 7.0 | 6.1 | 0.9 | 2.210** |
| | QU | | 1963–75 | | 5.6 | 1.4 | 2.929*** |
| NY | ON | 1960–72 | 1964–77 | 6.9 | 6.1 | 0.8 | 1.770* |
| | QU | | 1963–75 | | 5.6 | 1.3 | 2.503* |
| MI | NY | 1967–73 | 1950–53 | 6.8 | 6.4 | 0.4 | 0.358 |
| | NY | | 1960–67 | | 5.8 | 1.0 | 1.002 |
| | NY | | 1960–72 | | 5.5 | 1.3 | 1.439 |
| | ON | | 1964–77 | | 6.1 | 0.7 | 0.970 |
| MA | ME | 1968–71 | 1962–64 | 4.0 | 5.5 | −1.5 | −1.448* |
| | NY | | 1950–53 | | 6.4 | −2.4 | −2.513*** |
| | NY | | 1960–67 | | 5.8 | −1.8 | −1.109 |
| | NY | | 1960–72 | | 5.5 | −1.5 | −1.801* |
| | ON | | 1964–77 | | 6.1 | −2.1 | −2.985*** |
| | QU | | 1963–75 | | 5.7 | −1.7 | 2.281** |
| ME | NY | 1962–64 | 1950–53 | 5.5 | 6.4 | −0.9 | −0.865 |
| | NY | | 1960–67 | | 5.8 | −0.3 | −0.310 |
| | NY | | 1960–72 | | 5.5 | −0.0 | −0.038 |
| | QU | | 1963–75 | | 5.7 | −0.2 | −0.225 |

*$\alpha < 0.1$; **$\alpha < 0.05$; ***$\alpha < 0.01$.

Table I2. *Results of testing the hypothesis that adult female black duck recovery rates are the same in various states/provinces (preseason bandings).*

| Reference areas vs. | | Year comparisons vs. | | Mean recovery rate comparisons vs. | | Difference | Test statistic $z$ value |
|---|---|---|---|---|---|---|---|
| NY | ME | 1950–54 | 1961–66 | 9.9 | 5.8 | 4.1 | 1.602 |
| | MA | | 1968–71 | | 5.0 | 4.9 | 1.858* |
| | ON | | 1965–72 | | 5.5 | 4.5 | 1.686* |
| | QU | | 1968–71 | | 5.2 | 4.7 | 2.469*** |
| NY | ME | 1960–66 | 1961–66 | 5.0 | 5.8 | −0.8 | −0.800 |
| | MA | | 1968–71 | | 5.0 | 0.0 | 0.002 |
| | ON | | 1965–72 | | 5.5 | 0.4 | −0.409 |
| | QU | | 1968–71 | | 5.2 | 0.2 | 0.203 |
| ME | MA | 1961–66 | 1968–71 | 5.8 | 5.0 | 0.8 | 0.785 |
| | ON | | 1964–72 | | 5.5 | 0.3 | 0.317 |
| | QU | | 1968–71 | | 5.2 | 0.6 | 0.953 |
| MA | ON | 1968–71 | 1965–72 | 5.0 | 6.0 | −1.0 | −0.561 |
| | QU | | 1968–71 | | 5.5 | 0.5 | −0.613 |
| ON | QU | 1964–72 | 1968–71 | 5.5 | 5.2 | 0.2 | 0.467 |

$^*\alpha < 0.1$; $^{**}\alpha < 0.05$; $^{***}\alpha < 0.01$.

Table I3. *Results of testing tne hypothesis that young male black duck recovery rates are the same in various states/provinces (preseason bandings).*

| Reference areas vs. | | Year comparisons vs. | | Mean recovery rate comparisons vs. | | Difference | Test statistic $z$ value |
|---|---|---|---|---|---|---|---|
| NY | ON | 1950–53 | 1964–77 | 11.6 | 11.0 | −0.4 | −0.466 |
| | QU | | 1963–75 | | 11.1 | −0.5 | −0.527 |
| ON | QU | 1964–77 | 1963–75 | 11.0 | 11.1 | −0.1 | −0.146 |
| NY | ON | 1960–67 | 1964–77 | 12.8 | 11.0 | 1.8 | 3.234*** |
| | QU | | 1963–75 | | 11.1 | 1.7 | 2.677*** |
| NY | ON | 1960–72 | 1964–77 | 13.0 | 11.0 | 2.0 | 3.639*** |
| | QU | | 1963–75 | | 11.1 | 1.9 | 3.023*** |
| MI | NY | 1967–73 | 1950–53 | 7.1 | 10.6 | −3.5 | −3.492*** |
| | NY | | 1960–67 | | 12.8 | −5.7 | −7.090*** |
| | NY | | 1960–72 | | 13.0 | 5.9 | 7.545*** |
| | ON | | 1964–77 | | 11.0 | −3.9 | −5.257*** |
| MA | ME | 1968–71 | 1962–64 | 9.6 | 9.2 | 0.4 | 0.425 |
| | NY | | 1950–53 | | 10.6 | −1.0 | −0.965 |
| | NY | | 1960–67 | | 12.8 | −3.2 | −3.588*** |
| | NY | | 1960–72 | | 13.0 | 3.4 | 3.874*** |
| | ON | | 1964–77 | | 11.0 | −1.4 | −1.701* |
| | QU | | 1963–75 | | 9.4 | −1.5 | −1.684* |
| ME | NY | 1962–64 | 1950–53 | 9.2 | 10.6 | −1.5 | −1.539 |
| | NY | | 1960–67 | | 12.8 | −3.7 | −5.051*** |
| | NY | | 1960–72 | | 13.0 | 3.8 | 5.512*** |
| | ON | | 1964–77 | | 11.0 | −1.9 | −2.829*** |
| | QU | | 1963–75 | | 9.4 | −1.9 | −2.659*** |

$^*\alpha < 0.1$; $^{***}\alpha < 0.01$.

Table I4. *Results of testing the hypothesis that young female black duck recovery rates are the same in various states/provinces (preseason bandings).*

| Reference areas | vs. | Year comparisons | vs. | Mean recovery rate comparisons | vs. | Difference | Test statistic z value |
|---|---|---|---|---|---|---|---|
| NY | MA | 1950–54 | 1968–71 | 10.1 | 8.4 | 1.7 | 1.581 |
| | ME | | 1961–66 | | 11.8 | −1.7 | −1.990** |
| | ON | | 1964–72 | | 10.2 | −0.2 | −0.204 |
| | QU | | 1968–71 | | 10.8 | −0.7 | −0.850 |
| NY | MA | 1960–66 | 1968–71 | 11.6 | 8.4 | 3.2 | 3.279*** |
| | ME | | 1961–66 | | 11.8 | −0.2 | −0.326 |
| | ON | | 1964–72 | | 10.2 | −1.3 | 2.012** |
| | QU | | 1968–71 | | 10.8 | 0.7 | 0.977 |
| ME | ON | 1961–66 | 1964–72 | 11.8 | 10.2 | 1.6 | 2.325** |
| | QU | | 1968–71 | | 10.8 | 1.0 | 1.109 |
| MA | ON | 1968–71 | 1964–72 | 8.4 | 10.2 | −2.0 | −2.139** |
| | QU | | 1968–71 | | 13.1 | −4.5 | −4.252*** |
| ON | QU | 1964–72 | 1968–71 | 10.2 | 10.8 | 0.6 | −0.739 |

**$\alpha < 0.05$; ***$\alpha < 0.01$.

Table I5. *Results of testing the hypothesis that adult black duck recovery rates are the same in various major reference areas (preseason bandings).*

| Reference area comparisons | vs. | Year comparisons | vs. | Mean recovery rate comparisons | vs. | Difference | Test statistic z value |
|---|---|---|---|---|---|---|---|
| **Male** | | | | | | | |
| E Lake Ont (12) | W Lake Ont (13) | 1960–72 | 1965–72 | 6.9 | 6.6 | 0.3 | 0.636 |
| | Up Gt Lakes (15) | | 1964–68 | | 6.5 | 0.5 | 0.817 |
| | S Que (04) | | 1968–75 | | 6.4 | 0.5 | 1.104 |
| W Lake Ont (13) | S Que (04) | 1965–68 | 1968–75 | 6.6 | 6.4 | 0.2 | 0.398 |
| | Up Gt Lakes (15) | | 1964–68 | | 6.5 | 0.2 | 0.273 |
| **Female** | | | | | | | |
| Maritimes (01) | S Que (04) | 1970–74 | 1968–71 | 6.4 | 5.9 | 0.5 | 0.495 |
| | E Lake Ont (12) | | 1960–70 | | 5.1 | 1.2 | 1.309 |
| | W Lake Ont (13) | | 1965–68 | | 5.9 | 0.4 | −0.433 |
| | Up Gt Lakes (15) | | 1964–68 | | 6.4 | 0.1 | 0.076 |
| S Que (04) | E Lake Ont (12) | 1968–71 | 1960–70 | 5.9 | 5.1 | 0.8 | −0.856 |
| | W Lake Ont (13) | | 1965–68 | | 5.9 | 0.0 | −0.013 |
| | Up Gt Lakes (15) | | 1964–68 | | 6.4 | −0.5 | −0.493 |
| E Lake Ont (12) | W Lake Ont (13) | 1960–70 | 1965–68 | 5.1 | 5.9 | −0.8 | −0.850 |
| | Up Gt Lakes (15) | | 1964–68 | | 6.4 | −1.3 | −1.267 |
| W Lake Ont (13) | Up Gt Lakes (15) | 1965–68 | 1964–68 | 5.9 | 6.4 | −0.5 | −0.473 |

Table I6. *Results of testing the hypothesis that young black duck survival rates are the same in various minor reference areas (preseason bandings).*

| Reference area comparisons | vs. | Year comparisons | vs. | Mean recovery rate comparisons | vs. | Difference | Test statistic z value |
|---|---|---|---|---|---|---|---|
| **Male** | | | | | | | |
| E Lake Ont (12) | W Lake Ont (13) | 1960–72 | 1965–72 | 12.4 | 12.3 | 0.1 | 0.107 |
| | Up Gt Lakes (15) | | 1964–68 | | 9.6 | 2.8 | 3.203*** |
| | S Que (04) | | 1968–75 | | 12.4 | 0.1 | 0.076 |
| W Lake Ont (13) | S Que (04) | 1965–68 | 1968–75 | 12.3 | 12.4 | 0.1 | 0.158 |
| | Up Gt Lakes (15) | | 1964–68 | | 9.6 | 2.7 | 2.934*** |
| **Female** | | | | | | | |
| Maritimes (01) | S Que (04) | 1970–74 | 1968–71 | 11.8 | 12.4 | −0.7 | −0.654 |
| | E Lake Ont (12) | | 1960–70 | | 12.2 | −0.5 | 0.691 |
| | W Lake Ont (13) | | 1965–68 | | 11.4 | 0.4 | 0.426 |
| | Up Gt Lakes (15) | | 1964–68 | | 8.5 | 3.2 | 3.341*** |
| S Que (04) | E Lake Ont (12) | 1968–71 | 1960–70 | 12.4 | 12.2 | 0.2 | 0.207 |
| | W Lake Ont (13) | | 1965–68 | | 11.4 | 1.1 | 0.925 |
| | Up Gt Lakes (15) | | 1964–68 | | 8.5 | 3.9 | 3.272*** |
| E Gt Lakes (12) | W Lake Ont (13) | 1960–70 | 1965–68 | 12.2 | 11.4 | 0.9 | 1.013 |
| | Up Gt Lakes (15) | | 1964–68 | | 8.5 | 3.7 | 4.066*** |
| W Gt Lakes (13) | Up Gt Lakes (15) | 1965–68 | 1964–68 | 11.4 | 8.5 | 2.9 | 2.609*** |

***$\alpha < 0.01$.

Table I7. *Results of testing the hypothesis that adult black duck recovery rates are the same in various minor reference areas (preseason bandings).*

| Reference area comparisons | vs. | Year comparisons | vs. | Mean recovery rate comparisons | vs. | Difference | Test statistic z value |
|---|---|---|---|---|---|---|---|
| **Male** | | | | | | | |
| Que (041) | NY (122) | 1968–75 | 1960–68 | 6.3 | 7.3 | −0.9 | −2.648*** |
| | Ont (131) | | 1965–72 | | 6.8 | −0.5 | −0.899 |
| NY (122) | Ont (131) | 1960–68 | 1965–72 | 7.3 | 6.8 | 0.5 | 0.895 |
| **Female** | | | | | | | |
| Que (041) | Mass (081) | 1968–71 | 1969–71 | 5.9 | 4.5 | 1.4 | 1.369 |
| | NY (122) | | 1960–65 | | 5.0 | 0.9 | 0.830 |
| Mass (081) | NY (122) | 1969–71 | 1960–65 | 4.5 | 5.0 | −0.5 | −0.477 |

***$\alpha < 0.01$.

Table I8. *Results of testing the hypothesis that young black duck recovery rates are the same in various minor reference areas (preseason bandings).*

| Reference area comparisons vs. | | Year comparisons vs. | | Mean recovery rate comparisons vs. | | Difference | Test statistic $z$ value |
|---|---|---|---|---|---|---|---|
| **Male** | | | | | | | |
| Que (041) | NY (122) | 1968–75 | 1960–68 | 12.4 | 12.3 | 0.1 | 0.214 |
| | Ont (131) | | 1965–72 | | 11.0 | 1.4 | 2.798*** |
| NY (122) | Ont (131) | 1960–68 | 1965–72 | 12.3 | 11.0 | 1.3 | 2.602*** |
| **Female** | | | | | | | |
| Que (041) | Mass (081) | 1968–71 | 1969–71 | 12.4 | 7.4 | 5.1 | 4.076*** |
| | NY (122) | | 1960–65 | | 10.9 | 1.5 | 1.455 |
| Mass (081) | NY (122) | 1969–71 | 1960–65 | 7.4 | 10.9 | −3.5 | −3.371*** |

***$\alpha < 0.01$.

Table I9. *Results of testing the hypothesis that adult male black duck survival rates are the same in various states/provinces (preseason bandings).*

| Reference areas vs. | | Year comparisons vs. | | Mean recovery rate comparisons vs. | | Difference | Test statistic $z$ value |
|---|---|---|---|---|---|---|---|
| NY | ON | 1950–53 | 1964–77 | 53.4 | 61.5 | −8.1 | −1.676* |
| | QU | | 1963–75 | | 64.8 | −11.4 | −2.306** |
| ON | QU | 1964–77 | 1963–75 | 61.5 | 64.8 | −3.3 | −1.724* |
| NY | ON | 1960–67 | 1964–77 | 56.5 | 61.5 | −4.9 | −2.490** |
| | QU | | 1963–75 | | 64.8 | −8.3 | −3.658*** |
| NY | ON | 1960–72 | 1964–77 | 60.6 | 61.5 | −0.9 | −0.170 |
| | QU | | 1963–75 | | 64.8 | −4.2 | −0.774 |
| MI | NY | 1967–73 | 1950–53 | 63.4 | 53.4 | 10.0 | 1.891* |
| | NY | | 1960–67 | | 56.5 | 6.8 | 2.360** |
| | NY | | 1960–72 | | 60.6 | 2.8 | 0.479 |
| | ON | | 1964–77 | | 61.5 | 1.9 | 0.706 |
| MA | ME | 1968–71 | 1962–64 | 74.5 | 64.9 | 9.7 | 1.234 |
| | NY | | 1950–53 | | 53.4 | 21.1 | 2.416** |
| | NY | | 1960–67 | | 56.5 | 18.0 | 2.381** |
| | NY | | 1960–72 | | 60.6 | 14.0 | 1.541* |
| | ON | | 1964–77 | | 61.5 | 13.0 | 1.747* |
| | QU | | 1963–75 | | 64.8 | 9.7 | 3.224*** |
| ME | NY | 1962–64 | 1950–53 | 64.9 | 53.4 | 11.5 | 2.143* |
| | NY | | 1960–67 | | 56.5 | 8.4 | 2.731*** |
| | NY | | 1960–72 | | 60.6 | 4.3 | 0.736 |
| | QU | | 1963–75 | | 64.8 | 0.7 | 0.232 |

*$\alpha < 0.1$; **$\alpha < 0.05$; ***$\alpha < 0.01$.

Table I10. *Results of testing the hypothesis that adult female black duck survival rates are the same in various states/provinces (preseason bandings).*

| Reference areas vs. | | Year comparisons vs. | | Mean recovery rate comparisons vs. | | Difference | Test statistic z value |
|---|---|---|---|---|---|---|---|
| NY | ME | 1950–54 | 1961–66 | 50.0 | 50.7 | −0.7 | −0.054 |
| | MA | | 1968–71 | | 49.8 | 0.2 | 1.011 |
| | ON | | 1964–71 | | 65.1 | −15.1 | −0.804 |
| | QU | | 1968–71 | | 62.6 | −12.6 | −1.040 |
| NY | ME | 1960–66 | 1961–66 | 53.4 | 50.7 | 2.7 | 0.281 |
| | MA | | 1968–71 | | 49.8 | 3.6 | 0.215 |
| | ON | | 1964–71 | | 65.1 | −11.7 | −0.684 |
| | QU | | 1968–71 | | 62.6 | −9.3 | −0.981 |
| ME | MA | 1961–66 | 1968–71 | 50.7 | 49.8 | −0.9 | 0.060 |
| | ON | | 1964–72 | | 65.1 | −14.4 | −1.078 |
| | QU | | 1968–71 | | 61.0 | −10.3 | −2.477** |
| MA | ON | 1968–71 | 1964–71 | 49.8 | 65.1 | −15.3 | −0.374 |
| | QU | | 1968–71 | | 62.6 | −12.8 | 0.701 |
| ON | QU | 1964–72 | 1968–71 | 65.1 | 61.0 | 4.1 | 0.306 |

*$\alpha < 0.1$; **$\alpha < 0.05$.

Table I11. *Results of testing the hypothesis that young male black duck survival rates are the same in various states/provinces (preseason bandings).*

| Reference areas vs. | | Year comparisons vs. | | Mean recovery rate comparisons vs. | | Difference | Test statistic z value |
|---|---|---|---|---|---|---|---|
| NY | ON | 1950–53 | 1964–77 | 43.3 | 47.3 | −4.0 | −0.495 |
| | QU | | 1963–75 | | 38.8 | 4.5 | 0.551 |
| ON | QU | 1964–77 | 1963–75 | 47.3 | 38.8 | 8.6 | 2.196** |
| NY | ON | 1960–67 | 1964–77 | 44.1 | 47.3 | −3.2 | −0.771 |
| | QU | | 1963–75 | | 38.8 | 5.3 | 1.211 |
| NY | ON | 1960–72 | 1964–77 | 45.6 | 47.3 | −1.8 | −0.400 |
| | QU | | 1963–75 | | 38.8 | 6.8 | 1.472 |
| MI | NY | 1967–73 | 1950–53 | 43.0 | 43.3 | −0.3 | −0.030 |
| | NY | | 1960–67 | | 44.1 | −1.1 | −0.173 |
| | NY | | 1960–72 | 43.0 | 54.5 | 11.5 | 1.156 |
| | NY | | 1964–77 | | 47.3 | −4.3 | −0.736 |
| MA | ME | 1968–71 | 1962–64 | 58.2 | 45.3 | 12.9 | 0.978 |
| | NY | | 1950–53 | | 43.3 | 14.9 | 1.082 |
| | NY | | 1960–67 | | 44.1 | 14.1 | 1.189 |
| | NY | | 1960–72 | | 54.5 | −3.6 | −0.256 |
| | ON | | 1964–77 | | 47.3 | 10.8 | 0.928 |
| | QU | | 1963–75 | | 38.8 | 11.4 | 1.653 |
| ME | NY | 1962–64 | 1950–53 | 45.2 | 43.3 | 2.0 | 0.191 |
| | NY | | 1960–67 | | 44.1 | 1.2 | 0.155 |
| | NY | | 1960–72 | 45.3 | 54.5 | 9.3 | 0.860 |
| | ON | | 1964–77 | | 47.3 | −2.1 | −0.289 |
| | QU | | 1963–75 | | 38.8 | 6.5 | 0.888 |

**$\alpha < 0.05$.

Table I12. *Results of testing the hypothesis that young female black duck survival rates are the same in various states/provinces (preseason bandings).*

| Reference areas | vs. | Year comparisons | vs. | Mean recovery rate comparisons | vs. | Difference | Test statistic z value |
|---|---|---|---|---|---|---|---|
| NY | MA | 1950–54 | 1968–71 | 30.3 | 41.4 | −11.1 | −0.892 |
| | ME | | 1961–66 | | 45.2 | −14.9 | −1.661* |
| | ON | | 1964–71 | | 43.0 | −12.7 | −1.661* |
| | QU | | 1968–71 | | 40.1 | −9.8 | −1.186 |
| NY | MA | 1960–66 | 1968–71 | 44.4 | 41.4 | 3.0 | 0.238 |
| | ME | | 1961–66 | | 45.2 | −0.8 | −0.094 |
| | ON | | 1964–71 | | 43.0 | 1.4 | 0.182 |
| | QU | | 1968–71 | | 40.1 | 4.3 | 0.529 |
| ME | ON | | 1964–72 | 45.2 | 43.0 | 2.2 | 0.312 |
| | QU | | 1968–71 | | 38.2 | 7.1 | 0.884 |
| MA | ON | 1968–71 | 1964–71 | 41.4 | 52.6 | −11.2 | −0.818 |
| | QU | | 1968–71 | | 41.5 | −0.1 | −0.002 |
| ON | QU | 1964–72 | 1968–71 | 43.0 | 38.2 | 4.8 | 0.780 |

$^*\alpha < 0.1$.

Table I13. *Results of testing the hypothesis that adult black duck survival rates are the same in various major reference areas (preseason bandings).*

| Reference area comparisons | vs. | Year comparisons | vs. | Mean recovery rate comparisons | vs. | Difference | Test statistic z value |
|---|---|---|---|---|---|---|---|
| **Male** | | | | | | | |
| E Lake Ont (12) | W Lake Ont (13) | 1960–72 | 1965–72 | 58.1 | 62.3 | −4.2 | −1.766* |
| | Up Gt Lakes (15) | | 1964–68 | | 63.9 | −5.8 | −1.648* |
| | S Que (04) | | 1968–75 | | 66.0 | −8.0 | −3.022*** |
| W Lake Ont (13) | S Que (04) | 1965–72 | 1968–75 | 62.3 | 66.0 | −3.8 | −1.216 |
| | Up Gt Lakes (15) | | 1964–68 | | 63.9 | −1.6 | −0.416 |
| **Female** | | | | | | | |
| Maritimes (01) | S Que (04) | 1970–74 | 1968–71 | 43.8 | 60.0 | −16.2 | −2.502** |
| | E Lake Ont (12) | | 1960–70 | | 52.1 | −8.3 | −1.013 |
| | W Lake Ont (13) | | 1965–68 | | 48.3 | −4.4 | −0.701 |
| | Up Gt Lakes (15) | | 1964–68 | | 49.9 | −6.0 | −1.142 |
| S Que (04) | E Lake Ont (12) | 1968–71 | 1960–70 | 60.0 | 52.1 | 7.9 | 0.908 |
| | W Lake Ont (13) | | 1965–68 | | 48.3 | 11.8 | 1.665* |
| | Up Gt Lakes (15) | | 1964–68 | | 49.9 | 10.2 | 1.647* |
| E Lake Ont (12) | W Lake Ont (13) | 1960–70 | 1965–68 | 52.1 | 48.3 | 3.8 | 0.443 |
| | Up Gt Lakes (15) | | 1964–68 | | 49.9 | 2.2 | 0.280 |
| W Lake Ont (13) | Up Gt Lakes (15) | 1965–68 | 1964–68 | 48.3 | 49.9 | −1.6 | −0.268 |

$^*\alpha < 0.1$; $^{**}\alpha < 0.05$; $^{***}\alpha < 0.01$.

Table I14. *Results of testing the hypothesis that young black duck survival rates are the same in various major reference areas (preseason bandings).*

| Reference area comparisons vs. | | Year comparisons vs. | | Mean recovery rate comparisons vs. | | Difference | Test statistic $z$ value |
|---|---|---|---|---|---|---|---|
| **Male** | | | | | | | |
| E Lake Ont (12) | W Lake Ont (13) | 1960–72 | 1965–72 | 43.6 | 44.5 | −0.9 | −0.189 |
| | Up Gt Lakes (15) | | 1964–68 | | 50.3 | −6.7 | −1.046 |
| | S Que (04) | | 1968–75 | | 43.6 | −8.1 | −1.851* |
| W Lake Ont (13) | S Que (04) | 1965–72 | 1968–75 | 44.5 | 43.6 | −8.9 | −1.735* |
| | Up Gt Lakes (15) | | 1964–68 | | 50.3 | −5.8 | −0.835 |
| **Female** | | | | | | | |
| Maritimes (01) | S Que (04) | 1970–74 | 1968–71 | 36.3 | 43.2 | −7.0 | −0.739 |
| | E Lake Ont (12) | | 1960–70 | | 44.1 | −7.8 | −1.000 |
| | W Lake Ont (13) | | 1965–68 | | 58.9 | −22.6 | −1.848* |
| | Up Gt Lakes (15) | | 1964–68 | | 55.6 | −19.4 | −1.837* |
| S Que (04) | E Lake Ont (12) | 1968–71 | 1960–70 | 43.2 | 44.1 | −0.9 | −0.096 |
| | W Lake Ont (13) | | 1965–68 | | 58.9 | −15.7 | −1.205 |
| | Up Gt Lakes (15) | | 1964–68 | | 55.6 | −12.4 | −1.087 |
| E Lake Ont (12) | W Lake Ont (13) | 1960–70 | 1965–68 | | 58.9 | −14.8 | −1.244 |
| | Up Gt Lakes (15) | | 1964–68 | | 55.6 | −11.6 | −1.139 |
| W Lake Ont (13) | Up Gt Lakes (15) | 1965–68 | 1964–68 | 58.9 | 55.6 | 3.3 | 0.235 |

*$\alpha < 0.1$.

Table I15. *Results of testing the hypothesis that adult black duck survival rates are the same in various minor reference areas (preseason bandings).*

| Reference area comparisons vs. | | Year comparisons vs. | | Mean recovery rate comparisons vs. | | Difference | Test statistic $z$ value |
|---|---|---|---|---|---|---|---|
| **Male** | | | | | | | |
| Que (041) | NY (122) | 1968–75 | 1960–68 | 67.4 | 56.8 | 10.7 | 3.915*** |
| | Ont (131) | | 1965–72 | | 59.3 | 8.1 | 2.765*** |
| NY (122) | Ont (131) | 1960–68 | 1965–72 | 56.8 | 59.3 | −2.5 | −1.104 |
| **Female** | | | | | | | |
| Que (041) | Mass (081) | 1968–71 | 1969–71 | 60.0 | 52.4 | 7.6 | 0.401 |
| | NY (122) | | 1960–65 | | 52.9 | 7.1 | 0.660 |
| Mass (081) | NY (122) | 1969–71 | 1960–65 | 52.4 | 52.9 | −0.5 | −0.025 |

***$\alpha < 0.01$.

Table I16. *Results of testing the hypothesis that young black duck survival rates are the same in various minor reference areas (preseason bandings).*

| Reference area comparisons vs. | | Year comparisons vs. | | Mean recovery rate comparisons vs. | | Difference | Test statistic $z$ value |
|---|---|---|---|---|---|---|---|
| **Male** | | | | | | | |
| Que (041) | NY (122) | 1968–75 | 1960–68 | 35.3 | 41.2 | −6.0 | −0.756 |
| | Ont (131) | | 1965–72 | | 41.4 | −6.1 | −0.743 |
| NY (122) | Ont (131) | 1960–68 | 1965–72 | 41.2 | 41.4 | −0.1 | 0.030 |
| **Female** | | | | | | | |
| Que (041) | Mass (081) | 1968–71 | 1969–71 | 43.2 | 35.2 | 8.0 | 0.545 |
| | NY (122) | | 1960–65 | | 44.3 | −1.1 | −0.108 |
| Mass (081) | NY (122) | 1969–71 | 1960–65 | 35.2 | 44.3 | −9.1 | −0.625 |

# Appendix J. Results of Testing the Hypothesis That Black Duck Recovery Rates or Survival Rates Are the Same in Various Reference Areas of Banding (Winter Bandings—Corresponding Years).

Table J1. *Results of testing the hypothesis that adult male black duck recovery rates are the same in various states (winter bandings—corresponding years).*

| States compared vs. | | Year comparisons | Mean recovery rate comparisons vs. | | Difference | Test statistic z value |
|---|---|---|---|---|---|---|
| VA | DE | 1965–1967 | 2.4 | 2.0 | 0.4 | 0.784 |
| MD | DE | 1961–1963 | 3.0 | 3.0 | 0.0 | 0.021 |
| MA | DE | 1963–1967 | 2.5 | 2.4 | 0.1 | 0.453 |
| MA | MD | 1967–1974 | 2.4 | 3.6 | –1.2 | –3.925*** |
| VA | MD | 1967–1972 | 3.0 | 3.7 | –0.6 | –1.382 |
| MD | NY | 1961–1963 | 3.0 | 3.8 | –0.8 | –1.276 |
| DE | NJ | 1960–1967 | 2.6 | 2.9 | –0.2 | –0.753 |
| MD | NJ | 1967–1974 | 3.0 | 2.4 | 0.0 | –0.021 |
| MA | NJ | 1963–1974 | 2.4 | 3.4 | –1.0 | –4.715*** |
| NY | NJ | 1960–1974 | 4.2 | 3.2 | 1.0 | 3.754*** |
| DE | NY | 1960–1967 | 2.6 | 3.5 | –1.0 | –2.688*** |
| ME | NY | 1960–1963 | 4.9 | 3.5 | 1.4 | 1.979** |
| MD | NY | 1967–1974 | 3.6 | 4.7 | –1.2 | –2.662*** |
| MA | NY | 1963–1974 | 2.4 | 4.3 | –1.9 | –6.924*** |
| MA | NC | 1963–1967 | 2.0 | 2.2 | 0.4 | 0.910 |
| MA | NC | 1969–1972 | 2.6 | 2.7 | –0.1 | –0.256 |
| VA | NC | 1965–1967 | 2.3 | 1.9 | 0.5 | 0.923 |
| VA | NC | 1969–1972 | 3.4 | 2.7 | 0.7 | 1.192 |
| IL | OH | 1968–1971 | 3.7 | 4.0 | –0.2 | –0.360 |
| MI | OH | 1967–1969 | 3.6 | 2.7 | 0.9 | 1.180 |
| IL | TN | 1968–1971 | 3.7 | 3.4 | 0.3 | 0.544 |
| MI | TN | 1964–1969 | 4.1 | 3.3 | 0.7 | 1.306 |
| OH | TN | 1967–1972 | 3.4 | 3.4 | 0.0 | 0.057 |
| MA | VA | 1965–1972 | 2.6 | 2.9 | –0.3 | –1.099 |

**$\alpha < 0.05$; ***$\alpha < 0.01$.

Table J2. *Results of testing the hypothesis that adult female black duck recovery rates are the same in various states (winter bandings—corresponding years).*

| States compared vs. | | Year comparisons | Mean recovery rate comparisons vs. | | Difference | Test statistic z value |
|---|---|---|---|---|---|---|
| MA | DE | 1963–1965 | 2.1 | 3.0 | –0.8 | –0.928 |
| NJ | DE | 1960–1965 | 2.2 | 2.5 | –0.3 | –0.634 |
| MA | MD | 1963–1965 | 2.1 | 2.3 | –0.1 | –0.157 |
| MA | MD | 1970–1972 | 2.4 | 2.6 | –0.3 | –0.371 |
| NJ | MD | 1960–1965 | 2.2 | 2.6 | –0.4 | –0.804 |
| NJ | MD | 1970–1973 | 3.0 | 2.7 | 0.3 | 0.456 |
| MA | NJ | 1963–1972 | 2.4 | 2.8 | 0.4 | –1.258 |

Table J3. *Results of testing the hypothesis that adult male black duck survival rates are the same in various states (winter bandings—corresponding years).*

| States compared vs. | | Year comparisons | Mean survival rate comparisons vs. | | Difference | Test statistic z value |
|---|---|---|---|---|---|---|
| VA | DE | 1965–1967 | 59.8 | 74.0 | 14.1 | –1.040 |
| MD | DE | 1961–1963 | 74.1 | 74.0 | 0.1 | 0.024 |
| MA | DE | 1963–1967 | 73.3 | 74.0 | –0.7 | –0.165 |
| MA | MD | 1967–1974 | 73.3 | 72.0 | 1.2 | 0.304 |
| VA | MD | 1967–1972 | 76.8 | 72.0 | 4.7 | 0.353 |
| MD | NY | 1961–1963 | 72.0 | 56.3 | 15.7 | 1.664* |
| DE | NJ | 1960–1967 | 74.0 | 63.8 | 10.2 | 1.261 |
| MD | NJ | 1967–1974 | 70.5 | 58.4 | 4.6 | 0.745 |
| MA | NJ | 1963–1974 | 73.3 | 66.3 | 6.9 | 1.525 |
| NY | NJ | 1960–1974 | 61.5 | 65.6 | –4.1 | –0.710 |
| DE | NY | 1960–1967 | 73.9 | 59.3 | 14.7 | 2.584** |
| ME | NY | 1960–1963 | 90.8 | 52.2 | 38.5 | 1.704* |
| MD | NY | 1967–1974 | 72.0 | 63.7 | 8.3 | 1.122 |
| MA | NY | 1963–1974 | 73.3 | 64.0 | 9.2 | 1.932* |
| MA | NC | 1963–1967 | 73.3 | 67.2 | 6.0 | 0.551 |
| MA | NC | 1969–1972 | 73.3 | 77.8 | –4.5 | –0.200 |
| VA | NC | 1965–1967 | 59.8 | 62.2 | –2.3 | –0.113 |
| VA | NC | 1969–1972 | 79.0 | 77.8 | 1.2 | 0.042 |
| IL | OH | 1968–1971 | 88.1 | 66.3 | 21.8 | 1.317 |
| MI | OH | 1967–1969 | 52.9 | 81.1 | –28.2 | –1.407 |
| IL | TN | 1968–1971 | 88.1 | 59.8 | 28.2 | 1.924* |
| MI | TN | 1964–1969 | 56.8 | 72.9 | –16.1 | –1.526 |
| OH | TN | 1967–1972 | 78.6 | 71.4 | 7.2 | 0.479 |
| MA | VA | 1965–1972 | 73.3 | 71.9 | 1.3 | 0.133 |

*$\alpha < 0.1$; **$\alpha < 0.05$.

Table J4. *Results of testing the hypothesis that adult female black duck survival rates are the same in various states (winter bandings—corresponding years).*

| States compared | vs. | Year comparisons | Mean survival rate comparisons | vs. | Difference | Test statistic $z$ value |
|---|---|---|---|---|---|---|
| MA | DE | 1963–1965 | 47.9 | 61.5 | −13.6 | −0.537 |
| NJ | DE | 1960–1965 | 53.3 | 57.0 | −3.8 | −0.182 |
| MA | MD | 1963–1965 | 47.9 | 51.1 | −3.2 | −0.123 |
| MA | MD | 1970–1972 | 73.1 | 68.7 | 4.4 | 0.144 |
| NJ | MD | 1960–1965 | 53.3 | 54.0 | −0.8 | −0.012 |
| NJ | MD | 1970–1973 | 56.3 | 57.1 | −0.8 | −0.043 |
| MA | NJ | 1963–1972 | 57.5 | 66.2 | 2.5 | 0.271 |

# Appendix K. Results of Testing the Hypothesis That Black Duck Recovery Rates or Survival Rates Are the Same in Various Reference Areas of Banding (Winter Bandings—Noncorresponding Years).

Table K1. *Results of testing the hypothesis that adult male black duck recovery rates are the same in various states (winter bandings).*

| Reference areas | vs. | Year comparisons | vs. | Mean recovery rate comparisons | vs. | Difference | Test statistic $z$ value |
|---|---|---|---|---|---|---|---|
| ME | MA | 1960–63 | 1939–42 | 6.0 | 3.4 | 2.7 | 4.152*** |
| | MA | | 1967–74 | | 2.7 | 3.4 | 5.976*** |
| | NJ | | 1952–57 | | 5.4 | 0.6 | 0.926 |
| | NJ | | 1963–76 | | 3.9 | 2.3 | 4.016*** |
| | NY | | 1957–76 | | 4.3 | 1.8 | 3.183*** |
| MA | NJ | 1967–74 | 1952–57 | 2.7 | 5.3 | 2.5 | −4.289*** |
| | NJ | | 1963–76 | | 3.9 | 1.1 | −5.337*** |
| | NY | | 1957–76 | | 4.5 | 1.8 | −7.541*** |
| | DE | | 1960–65 | | 3.5 | 0.8 | −1.998** |
| | MD | | 1967-73 | | 3.9 | 1.2 | −3.475*** |
| NJ | NY | 1952–57 | 1957–76 | 5.4 | 4.3 | 1.0 | 1.503 |
| | NC | | 1962–72 | | 2.8 | 2.6 | 3.725*** |
| | VA | | 1965–72 | | 3.5 | 1.9 | 2.609*** |
| NJ | NY | 1963–76 | 1957–76 | 3.9 | 4.3 | 0.4 | 2.061** |
| | NC | | 1962–72 | | 2.8 | 1.1 | 1.958* |
| | VA | | 1965–72 | | 3.5 | 0.4 | 0.701 |
| DE | MD | 1960–65 | 1967–73 | 3.8 | 3.9 | −0.1 | −0.321 |
| | NJ | | 1952–57 | | 5.4 | −1.6 | −2.116** |
| | NJ | | 1963–76 | | 3.9 | −0.1 | −0.328 |
| | NY | | 1957–76 | | 4.3 | −0.6 | −1.431 |
| | NC | | 1962–72 | | 2.8 | 1.0 | 2.342** |
| | VA | | 1965–72 | | 3.5 | 0.3 | 0.632 |
| MD | NJ | 1967–73 | 1952–57 | 3.9 | 5.4 | −1.4 | −2.001** |
| | NJ | | 1963–76 | | 3.9 | 0.0 | 0.069 |
| | NY | | 1957–75 | | 4.3 | −0.4 | −1.254 |
| | NC | | 1962–72 | | 2.8 | 1.1 | 3.138*** |
| | VA | | 1965–72 | | 3.5 | 0.5 | 1.066 |
| NY | NC | 1957–76 | 1962–72 | 4.3 | 2.8 | 1.6 | 5.765*** |
| | VA | | 1965–72 | | 3.5 | 0.9 | 2.524** |
| NC | VA | 1962–72 | 1965–72 | 2.8 | 3.5 | −0.7 | −1.860* |
| MI | NY | 1967–69 | 1957–76 | 4.3 | 4.3 | 0.0 | 0.006 |
| | OH | | 1969–74 | | 4.9 | −0.6 | −0.954 |
| | TN | | 1963–72 | | 4.2 | −0.1 | 0.415 |
| IL | MI | 1969–72 | 1967–69 | 4.4 | 4.3 | 0.1 | 0.130 |
| | OH | | 1969–74 | | 4.9 | −0.5 | 0.816 |
| | TN | | 1963–72 | | 4.2 | 0.3 | 0.999 |
| OH | TN | 1969–74 | 1963–72 | 4.9 | 4.2 | −0.8 | −1.528 |

$^{*}\alpha < 0.1$; $^{**}\alpha < 0.05$; $^{***}\alpha < 0.01$.

Table K2. *Results of testing the hypothesis that adult female black duck recovery rates are the same in various states (winter bandings).*

| Reference areas vs. | | Year comparisons vs. | | Mean recovery rate comparisons vs. | | Difference | Test statistic $z$ value |
|---|---|---|---|---|---|---|---|
| ME | MA | 1960–62 | 1963–76 | 6.0 | 2.9 | 3.1 | 3.432*** |
| | NJ | | 1965–76 | | 3.2 | 2.7 | 3.072*** |
| | NY | | 1959–61 | | 4.8 | 1.1 | 1.120 |
| | NY | | 1963–72 | | 4.2 | 1.7 | 1.943* |
| | NC | | 1963–72 | | 3.4 | 2.6 | 2.815*** |
| MA | NJ | 1963–76 | 1965–76 | 2.9 | 3.2 | −0.3 | −1.190 |
| | NY | | 1959–61 | | 4.8 | −1.9 | −3.491*** |
| | NY | | 1963–72 | | 4.2 | −1.3 | −3.969*** |
| | DE | | 1962–65 | | 3.8 | −0.9 | −1.566 |
| | MD | | 1957–63 | | 3.5 | −0.6 | −1.438 |
| NJ | NY | 1965–76 | 1959–61 | 3.2 | 4.8 | −1.6 | −2.930*** |
| | NY | | 1963–72 | | 4.2 | −1.0 | −3.091*** |
| | NC | | 1963–72 | | 3.4 | 0.2 | 0.459 |
| | VA | | 1965–71 | | 2.5 | 0.7 | 2.126** |
| DE | MD | 1962–65 | 1957–63 | 3.8 | 3.5 | 0.3 | 9.388 |
| | MD | | 1967–73 | | 3.4 | 0.4 | 0.616 |
| | NJ | | 1965–76 | | 3.2 | 0.6 | 0.991 |
| | NY | | 1959–61 | | 4.8 | −1.0 | −1.408 |
| | NY | | 1963–72 | | 4.2 | −0.4 | −0.701 |
| | NC | | 1963–72 | | 3.4 | 0.5 | 0.727 |
| | VA | | 1965–71 | | 2.5 | 1.3 | 2.111** |
| MD | NJ | 1957–63 | 1965–76 | 3.5 | 3.2 | 0.3 | 0.697 |
| | NY | | 1959–61 | | 4.8 | −1.3 | −2.009** |
| | NY | | 1963–72 | | 4.2 | −0.7 | −1.436 |
| | NC | | 1963–72 | | 3.4 | 0.2 | 0.392 |
| | VA | | 1965–71 | | 2.5 | 1.0 | 2.108** |
| MD | NJ | 1967–73 | 1965–76 | 3.4 | 3.2 | 0.2 | 0.351 |
| | NY | | 1959–61 | | 4.8 | −1.4 | −2.243** |
| | NY | | 1963–72 | | 4.2 | −0.8 | 1.759 |
| MD | NC | 1967–73 | 1963–72 | 3.4 | 3.4 | −0.1 | 0.104 |
| | VA | | 1965–71 | | 2.5 | 0.9 | 1.792* |
| NY | NC | 1959–61 | 1963–72 | 4.8 | 3.4 | 1.5 | 2.429** |
| | VA | | 1965–71 | | 2.5 | 2.3 | 3.968*** |
| NY | NC | 1963–72 | 1963–72 | 4.2 | 3.4 | 0.9 | 2.043** |
| | VA | | 1965–71 | | 2.5 | 1.7 | 4.520*** |
| NC | VA | 1963–72 | 1965–71 | 3.4 | 2.5 | 0.8 | 1.820* |
| IL | OH | 1969–72 | 1971–74 | 3.2 | 4.1 | 0.9 | 1.200 |
| | TN | | 1963–72 | | 4.3 | −1.2 | −3.075*** |

*$\alpha < 0.1$; **$\alpha < 0.05$; ***$\alpha < 0.01$.

Table K3. *Results of testing the hypothesis that adult male black duck recovery rates are the same in various major reference areas (winter bandings).*

| Reference area comparisons vs. | | Year comparisons vs. | | Mean survival rate comparisons vs. | | Difference | Test statistic z value |
|---|---|---|---|---|---|---|---|
| Maritimes (01) | Maine (02) | 1971–73 | 1960–63 | 3.3 | 6.1 | 2.8 | –3.405 |
| | S New Eng (03) | | 1972–76 | | 3.0 | 0.3 | 0.492 |
| | LI–Hudson R (04) | | 1957–59 | | 4.3 | 2.0 | 2.760*** |
| | Mid-Atl (05) | | 1952–56 | | 4.6 | –1.3 | –1.535 |
| | Mid-Atl (05) | | 1957–76 | | 3.6 | 0.3 | –0.490 |
| | Mid-Atl C (06) | | 1952–55 | | 6.2 | 2.9 | –2.953*** |
| | Mid-Atl C (06) | | 1959–76 | | 3.8 | –0.5 | –0.789 |
| Maine (02) | S New Eng (03) | 1960–63 | 1972–76 | 6.1 | 3.0 | 3.2 | 5.065*** |
| | LI–Hudson R (04) | | 1957–59 | | 1.3 | 4.8 | 7.426*** |
| | Mid-Atl (05) | | 1952–56 | | 4.6 | 1.5 | 1.904* |
| | Mid-Atl (05) | | 1957–76 | | 3.6 | 2.5 | 4.543*** |
| | Mid-Atl C (06) | | 1952–55 | | 6.2 | –0.1 | –0.065 |
| | Mid-Atl C (06) | | 1959–76 | | 3.8 | 2.3 | 4.150*** |
| S New Eng (03) | LI–Hudson R (04) | 1972–76 | 1957–59 | 3.0 | 1.3 | 1.6 | 3.523*** |
| | Mid-Atl (05) | | 1952–56 | | 4.6 | 1.7 | –2.514** |
| | Mid-Atl (05) | | 1957–76 | | 3.6 | 0.7 | –2.016** |
| | Mid-Atl C (06) | | 1952–55 | | 5.7 | –2.7 | –3.176*** |
| | Mid-Atl C (06) | | 1959–76 | | 3.8 | –0.9 | –2.557** |
| LI–Hudson R (04) | Mid-Atl (05) | 1957–59 | 1952–56 | 1.3 | 4.6 | –3.3 | –4.857*** |
| | Mid-Atl (05) | | 1957–76 | | 3.6 | –2.3 | –6.294*** |
| | Mid-Atl C (06) | | 1952–55 | | 6.2 | –4.9 | –5.879*** |
| | Mid-Atl C (06) | | 1959–76 | | 3.8 | –2.5 | –6.664*** |
| | Lake Ont (08) | | 1956–58 | | 8.0 | –6.7 | –5.716*** |
| | Lake Ont (08) | | 1963–74 | | 6.3 | –5.0 | –9.461*** |
| Mid-Atl (05) | Mid-Atl C (06) | 1952–56 | 1952–55 | 4.6 | 6.2 | –1.6 | –1.661* |
| | Mid-Atl C (06) | | 1959–76 | | 3.8 | 0.8 | 1.356 |
| | Lake Ont (08) | | 1956–58 | | 8.0 | –3.6 | –3.772*** |
| | Lake Ont (08) | | 1963–74 | | 6.3 | –1.7 | –2.468** |
| Mid-Atl (05) | Lake Erie (09) | 1952–56 | 1968–72 | 4.6 | 4.3 | 0.3 | 0.411 |
| Mid-Atl (05) | Mid-Atl C (06) | 1957–76 | 1952–55 | 3.6 | 6.2 | –2.6 | –3.403*** |
| | Mid-Atl C (06) | | 1959–76 | | 3.8 | –0.2 | –1.188 |
| | Lake Ont (08) | | 1956–58 | | 6.2 | –2.6 | –3.405*** |
| | Lake Ont (08) | | 1963–74 | | 6.3 | –2.7 | –6.640*** |
| | Lake Erie (09) | | 1968–72 | | 4.3 | –0.7 | –1.282 |
| Mid-Atl C (06) | Lake Ont (08) | 1952–55 | 1956–58 | 6.2 | 8.0 | –1.8 | –1.363 |
| | Lake Ont (08) | | 1963–74 | | 6.3 | –0.2 | –0.193 |
| | Lake Erie (09) | | 1968–72 | | 4.3 | 1.9 | 2.077** |
| Mid-Atl C (06) | Lake Ont (08) | 1959–76 | 1956–58 | 3.8 | 8.0 | –4.2 | –3.749*** |
| | Lake Ont (08) | | 1963–74 | | 6.3 | –2.5 | –6.056*** |
| | Lake Erie (09) | | 1968–72 | | 4.3 | –0.5 | –0.907 |
| Lake Ont (08) | Lake Erie (09) | 1956–58 | 1968–72 | 8.0 | 4.3 | 3.7 | 3.023*** |
| | Tenn R (11) | | 1963–71 | | 4.3 | 3.7 | 3.251*** |
| Lake Ont (08) | Lake Erie (09) | 1963–74 | 1968–72 | 6.3 | 4.3 | 2.1 | 3.139*** |
| | Tenn R (11) | | 1963–71 | | 4.3 | 2.0 | 4.391*** |
| Lake Erie (09) | Tenn R (11) | 1968–72 | 1963–71 | 4.3 | 4.3 | 0.0 | –0.017 |
| | Lake Mich (12) | | 1967–69 | | 4.8 | –0.5 | –0.632 |
| | Lake Mich (12) | | 1972–74 | | 3.6 | 0.7 | 0.907 |
| | Up Miss R (13) | | 1964–72 | | 4.3 | 0.1 | 0.113 |
| Tenn R (11) | Lake Mich (12) | 1963–71 | 1967–69 | 4.3 | 4.8 | –0.5 | –0.798 |

Table K3. *Continued.*

| Reference area comparisons vs. | | Year comparisons vs. | | Mean survival rate comparisons vs. | | Difference | Test statistic $z$ value |
|---|---|---|---|---|---|---|---|
| | Lake Mich (12) | | 1972–74 | | 3.6 | 0.7 | 1.130 |
| | Up Miss R (13) | | 1964–72 | | 4.3 | 0.1 | 0.229 |
| Lake Mich (12) | UP Miss R (13) | 1967–69 | 1964–72 | 4.8 | 4.3 | 0.5 | 0.948 |
| Lake Mich (12) | Up Miss R (13) | 1972–74 | 1964–72 | 3.6 | 4.3 | –0.7 | –1.032 |

* $\alpha < 0.1$; ** $\alpha < 0.05$; ***$\alpha < 0.01$.

Table K4. *Results of testing the hypothesis that adult female black duck recovery rates are the same in various major reference areas (winter bandings).*

| Reference area comparisons vs. | | Year comparisons vs. | | comparisons vs. | | Difference | Test statistic $z$ value |
|---|---|---|---|---|---|---|---|
| Maine (02) | S New Eng (03) | 1960–62 | 1939–42 | 6.0 | 4.3 | 1.6 | 1.561 |
| | S New Eng (03) | | 1963–76 | | 3.2 | 2.8 | 3.182*** |
| | Mid-Atl (05) | | 1964–73 | | 3.3 | 2.6 | 2.971*** |
| | Mid-Atl C (06) | | 1960–76 | | 3.0 | 2.8 | 3.207*** |
| S New Eng (03) | Mid-Atl (05) | 1939–42 | 1964–73 | 4.3 | 3.3 | 1.0 | 1.551 |
| | Mid-Atl C (06) | | 1960–76 | | 3.0 | 1.2 | 1.807* |
| S New Eng (03) | Mid-Atl (05) | 1963–76 | 1964–73 | 3.2 | 3.3 | –0.2 | –0.063 |
| | Mid-Atl C (06) | | 1960–76 | | 3.0 | 0.2 | 0.685 |
| Tenn R (11) | Up Miss R (13) | 1963–71 | 1964–72 | 4.4 | 4.2 | 0.2 | 0.488 |

* $\alpha < 0.1$; *** $\alpha < 0.01$.

Table K5. *Results of testing the hypothesis that adult male black duck recovery rates are the same in various minor reference areas (winter bandings).*

| Reference area comparisons | vs. | Year comparisons | vs. | Mean recovery rate comparisons | vs. | Difference | Test statistic z value |
|---|---|---|---|---|---|---|---|
| ME (021) | NH (031) | 1960–63 | 1966–68 | 6.2 | 8.7 | 2.5 | –1.790* |
| | MA (032) | | 1939–42 | | 3.4 | 2.7 | 4.152*** |
| | | | 1969–76 | | 1.9 | 4.3 | 7.127*** |
| | | | 1972–76 | | 3.0 | 3.2 | 5.159*** |
| | NY (042) | | 1957–59 | | 1.5 | 4.7 | 7.256** |
| | VA (051) | | 1966–72 | | 4.0 | 2.2 | 3.285** |
| | NC (052) | | 1962–72 | | 2.8 | 3.4 | 5.814*** |
| | DE (053) | | 1963–65 | | 3.6 | 2.6 | 3.408*** |
| | MD (055) | | 1961–63 | | 4.1 | 2.1 | 2.847** |
| | | | 1967–73 | | 4.0 | 2.2 | 3.564*** |
| | NJ (063) | | 1952–55 | | 5.2 | 1.0 | 1.233 |
| | | | 1959–61 | | 4.4 | 1.8 | 2.206* |
| | | | 1963–76 | | 3.9 | 2.3 | 4.086*** |
| | VA (064) | | 1965–68 | | 2.0 | 4.2 | 6.166*** |
| NH (031) | MA (032) | 1966–68 | 1939–42 | 8.7 | 3.4 | 5.3 | 3.839*** |
| | | | 1969–71 | | 3.5 | 5.2 | 5.075*** |
| | | | 1972–76 | | 2.9 | 5.8 | 4.256*** |
| | NY (042) | | 1957–59 | | 1.4 | 7.3 | 5.320*** |
| | VA (051) | | 1966–72 | | 4.0 | 4.7 | 3.445*** |
| | NC (052) | | 1962–72 | | 2.8 | 6.0 | 4.443*** |
| | DE (053) | | 1963–65 | | 3.6 | 5.1 | 3.605*** |
| | MD (055) | | 1961–63 | | 4.1 | 4.7 | 3.307*** |
| | | | 1967–73 | | 4.0 | 4.8 | 3.521*** |
| | NJ (063) | | 1952–55 | | 5.2 | 3.6 | 2.446* |
| | | | 1959–61 | | 4.4 | 4.4 | 2.995** |
| | | | 1963–76 | | 3.9 | 4.9 | 3.654*** |
| | VA (064) | | 1965–68 | | 2.0 | 6.7 | 4.865*** |
| MA (032) | NY (042) | 1969–76 | 1957–59 | 1.9 | 1.4 | 0.5 | 1.043 |
| | VA (051) | | 1966–72 | | 4.0 | –2.1 | –4.574*** |
| | NC (052) | | 1962–72 | | 2.8 | –0.9 | –2.674** |
| | DE (053) | | 1963–65 | | 3.6 | –1.7 | –2.960** |
| | MD (055) | | 1961–63 | | 4.0 | –2.1 | –3.711*** |
| | | | 1967–73 | | 4.0 | –2.1 | –5.231*** |
| | NJ (063) | | 1952–55 | | 4.1 | –2.2 | –4.634*** |
| | | | 1959–61 | | 3.3 | –1.4 | –3.754*** |
| | | | 1963–76 | | 4.1 | –2.2 | –6.738*** |
| | VA (064) | | 1965–68 | | 2.0 | –2.1 | –0.236 |
| | VA (051) | | 1966–72 | | 4.0 | –2.6 | –4.865*** |
| | NC (052) | | 1962–67 | | 2.8 | –1.4 | –3.200** |
| | DE (053) | | 1963–65 | | 3.6 | –2.2 | –3.431*** |
| | MD (055) | | 1961–63 | | 4.0 | –2.6 | –4.118*** |
| NY (0420 | MD (055) | 1957–59 | 1967–73 | 1.4 | 4.0 | –2.5 | –5.359*** |
| | NJ (063) | | 1952–55 | | 5.1 | –3.7 | –4.966*** |
| | | | 1959–61 | | 4.3 | –2.9 | –4.147*** |
| | | | 1963–76 | | 3.9 | –2.4 | –6.247*** |
| | VA (064) | | 1965–68 | | 2.0 | –0.6 | –1.059 |
| | NY (081) | | 1956–58 | | 6.0 | –5.6 | –5.373*** |
| | | | 1964–74 | | 6.5 | –5.1 | –9.166*** |
| VA (051) | NC (051) | 1966–72 | 1962–67 | 4.0 | 2.8 | 1.2 | 2.777** |
| | DE (053) | | 1963–65 | | 3.6 | 0.3 | 0.591 |
| | MD (055) | | 1961–63 | | 4.0 | 0.0 | –0.070 |

Table K5. *Continued.*

| Reference area comparisons | vs. | Year comparisons | vs. | Mean recovery rate comparisons | vs. | Difference | Test statistic z value |
|---|---|---|---|---|---|---|---|
| | | | 1967–73 | | 4.0 | 0.0 | 0.071 |
| | NJ (063) | | 1952–55 | | 5.1 | –1.1 | –1.511 |
| | | | 1959–61 | | 4.4 | –0.4 | –0.532 |
| | | | 1963–76 | | 3.9 | 0.1 | 0.295 |
| | VA (064) | | 1965–68 | | 2.0 | 2.0 | 3.585*** |
| | NY (081) | | 1956–58 | | 8.0 | –4.1 | –3.466*** |
| | | | 1964–74 | | 6.6 | –2.6 | –4.512 |
| NC (052) | DE (053) | 1962–72 | 1963–65 | 2.8 | 3.6 | –0.8 | –1.478 |
| | MD (055) | | 1961–63 | | 4.1 | –1.3 | –2.247* |
| | | | 1967–73 | | 4.0 | –1.2 | –3.194** |
| | NJ (063) | | 1952–55 | | 5.1 | –2.4 | –3.438*** |
| | NJ (063) | | 1959–61 | | 4.3 | –1.6 | –2.472* |
| | | | 1963–76 | | 3.9 | –1.1 | –4.226*** |
| | VA (064) | | 1965–68 | | 2.0 | 0.8 | 1.701* |
| | NY (081) | | 1956–58 | | 8.0 | –5.3 | –4.665*** |
| | | | 1964–74 | | 6.6 | –3.8 | –7.899*** |
| DE (053) | MD (055) | 1963–65 | 1961–63 | 3.6 | 4.0 | –0.4 | –0.581 |
| | | | 1967–73 | | 4.0 | 0.3 | –1.826* |
| | NJ (063) | | 1952–54 | | 5.1 | –1.5 | –1.898* |
| | | | 1959–61 | | 4.4 | –0.8 | –0.953 |
| | | | 1963–76 | | 3.9 | –0.3 | –0.482 |
| | VA (064) | | 1965–68 | | 2.0 | 1.6 | 2.439* |
| | NY (081) | | 1956–58 | | 8.0 | –4.4 | –3.630*** |
| | | | 1964–74 | | 6.6 | –3.0 | –4.410*** |
| MD (055) | NJ (063) | 1961–63 | 1952–55 | 4.0 | 5.1 | –1.1 | –1.316 |
| | | | 1959–61 | | 4.3 | –0.3 | –0.421 |
| | | | 1963–76 | | 3.9 | 0.2 | 0.308 |
| | VA (064) | | 1965–68 | | 2.0 | 2.0 | 3.098** |
| | NY (081) | | 1956–58 | | 8.0 | 4.0 | 3.285** |
| | | | 1964–74 | | 6.6 | –2.6 | –3.789*** |
| MD (055) | NJ (063) | 1967–73 | 1952–55 | 4.0 | 5.1 | –1.2 | –1.637 |
| | | | 1959–61 | | 4.3 | –0.4 | –0.612 |
| | | | 1963–76 | | 5.1 | 0.1 | 0.257 |
| | NC (052) | | 1965–68 | | 2.9 | 1.9 | 3.886*** |
| | NY (081) | | 1956–58 | | 8.0 | –4.1 | –3.566*** |
| | | | 1964–74 | | 6.6 | –2.6 | –5.000*** |
| NJ (063) | VA (064) | 1952–55 | 1965–68 | 5.1 | 2.0 | 3.1 | 4.088*** |
| | NY (081) | | 1956–58 | | 7.0 | –1.9 | –1.636 |
| | | | 1964–74 | | 6.6 | –1.5 | –1.870* |
| VA (064) | NY (081) | 1965–68 | 1956–58 | 2.0 | 8.0 | –6.0 | –5.123*** |
| | | | 1964–74 | | 6.6 | –4.6 | –7.785*** |
| NY (081) | IL (131) | 1956–58 | 1969–72 | 8.0 | 4.5 | 3.6 | 3.130** |
| NY (081) | TN (113) | 1956–58 | 1963–71 | 8.0 | 4.5 | –3.5 | 3.067** |
| | TN (133) | | 1964–72 | | 3.7 | 4.4 | 3.849*** |
| TN (113) | NY (081) | 1963–71 | 1964–74 | 4.5 | 6.6 | –2.0 | –3.988*** |
| | MI (123) | | 1967–73 | | 3.9 | 0.6 | 1.168 |
| | IL (131) | | 1969–72 | | 4.4 | 0.1 | 0.237 |
| | TN (133) | | 1964–72 | | 3.6 | 0.9 | 2.404* |
| TN (133) | IL (131) | 1964–72 | 1969–72 | 5.3 | 4.5 | –0.8 | –1.996* |
| MI (123) | IL (131) | 1967–73 | 1969–72 | 3.9 | 4.4 | –0.5 | –0.960 |
| | TN (133) | | 1964–72 | | 3.6 | 0.2 | 0.434 |

* $\alpha < 0.1$; ** $\alpha < 0.05$; *** $\alpha < 0.01$.

Table K6. *Results of testing the hypothesis that adult female black duck recovery rates are the same in various minor reference areas (winter bandings).*

| Reference area comparisons | vs. | Year comparisons | vs. | Mean recovery rate comparisons | vs. | Difference | Test statistic $z$ value |
|---|---|---|---|---|---|---|---|
| ME (021) | MA (032) | 1960–62 | 1963–72 | 5.9 | 3.0 | 2.9 | 3.304*** |
| | | | 1974–76 | | 2.7 | 3.3 | 3.244** |
| | NY (036) | | 1959–61 | | 5.0 | 0.9 | 0.883 |
| | | | 1963–70 | | 4.0 | 1.9 | 2.089* |
| | VA (051) | | 1966–71 | | 2.7 | 3.2 | 3.443*** |
| | NC (052) | | 1963–72 | | 3.3 | 2.6 | 2.857** |
| | MD (055) | | 1957–63 | | 3.5 | 2.4 | 2.547* |
| | | | 1967–69 | | 4.0 | 1.9 | 1.718* |
| | | | 1971–73 | | 2.8 | 3.1 | 3.217** |
| | NJ (063) | | 1965–76 | | 3.2 | 2.7 | 3.102** |
| MA (032) | NY (036) | 1963–72 | 1959–61 | 3.0 | 5.0 | –2.0 | –3.277** |
| | | | 1963–70 | | 4.0 | –1.0 | –2.581** |
| | VA (051) | | 1966–71 | | 2.7 | 0.3 | 0.613 |
| | NC (052) | | 1963–72 | | 3.3 | –0.4 | –0.910 |
| | MD (055) | | 1957–63 | | 3.5 | –0.6 | –1.201 |
| | | | 1967–69 | | 4.0 | –1.0 | –1.329 |
| | | | 1971–73 | | 2.8 | –0.2 | –0.326 |
| | NJ (063) | | 1965–76 | | 3.2 | –0.2 | –0.720 |
| MA (032) | NY (036) | 1974–76 | 1959–61 | 2.7 | 5.0 | –2.3 | –3.038** |
| | | | 1963–70 | | 4.0 | –1.3 | –2.205* |
| | VA (051) | | 1966–71 | | 2.7 | –0.0 | –0.049 |
| | NC (052) | | 1963–72 | | 3.3 | –0.6 | –1.081 |
| | MD (055) | | 1957–63 | | 3.5 | –0.8 | –1.308 |
| | | | 1967–69 | | 4.0 | –1.3 | –1.471 |
| | | | 1971–73 | | 2.8 | –0.1 | –0.176 |
| | NJ (063) | | 1965–76 | | 3.2 | –0.6 | –1.019 |
| NY (036) | VA (051) | 1959–61 | 1966–71 | 5.0 | 2.7 | 2.3 | 3.450* |
| | NC (052) | | 1963–72 | | 3.3 | 1.7 | 2.612* |
| | MD (055) | | 1957–63 | | 3.5 | 1.5 | 2.153* |
| | | | 1967–69 | | 4.0 | 1.0 | 1.104 |
| NY (036) | MD (055) | 1959–61 | 1971–73 | 5.0 | 2.8 | 2.2 | 3.034** |
| | NJ (063) | | 1965–76 | | 3.2 | 1.8 | 2.939** |
| NY (036) | VA (051) | 1963–70 | 1966–71 | 4.0 | 2.7 | 1.3 | 2.778** |
| | NC (052) | | 1963–72 | | 3.3 | 0.7 | 1.565 |
| | MD (055) | | 1957–63 | | 3.5 | 0.5 | 0.968 |
| | | | 1967–69 | | 4.0 | 0.0 | 0.024 |
| | | | 1971–73 | | 2.8 | 1.2 | 2.187* |
| | NJ (063) | | 1965–76 | | 3.2 | 0.8 | 2.073* |
| VA (051) | NC (052) | 1966–71 | 1963–72 | 2.7 | 3.3 | –0.6 | –1.343 |
| | MD (055) | | 1957–63 | | 3.5 | –0.8 | –1.566 |
| | | | 1967–69 | | 4.0 | –1.3 | –1.590 |
| | | | 1971–73 | | 2.8 | –0.1 | –0.160 |
| | NJ (063) | | 1965–76 | | 3.2 | –0.5 | –1.347 |
| NC (052) | MD (055) | 1963–72 | 1957–63 | 3.3 | 3.5 | –0.2 | –0.436 |
| | | | 1967–79 | | 4.0 | –0.7 | –0.866 |
| | | | 1971–73 | | 2.8 | 0.5 | 0.906 |
| | NJ (063) | | 1965–76 | | 3.2 | 0.1 | 0.296 |
| MD (055) | NJ (063) | 1957–63 | 1965–76 | 3.5 | 3.2 | 0.3 | 0.657 |
| | | 1967–69 | 1965–76 | 4.0 | 3.2 | 0.8 | −1.061 |
| | | 1971–73 | 1965–76 | 2.8 | 3.2 | –0.4 | –0.890 |
| TN (113) | IL (131) | 1963–71 | 1969–72 | 4.8 | 3.2 | 1.6 | 3.610*** |
| | | TN (133) | 1965–72 | | 4.2 | 0.6 | 1.334 |
| IL (131) | TN (133) | 1969–72 | 1965–72 | 3.2 | 4.2 | 1.0 | –2.273** |

* $\alpha < 0.1$; ** $\alpha < 0.05$; *** $\alpha < 0.01$.

Table K7. *Results of testing the hypothesis that adult male black duck survival rates are the same in various states (winter bandings).*

| Reference areas vs. | | Year comparisons vs. | | Mean survival rate comparisons vs. | | Difference | Test statistic $z$ value |
|---|---|---|---|---|---|---|---|
| ME | MA | 1960–63 | 1939–42 | 83.5 | 77.2 | 6.3 | 0.496 |
| | MA | | 1967–74 | | 75.3 | 8.2 | 0.662 |
| | NJ | | 1952–57 | | 64.0 | 19.5 | 1.422 |
| | NJ | | 1963–76 | | 68.8 | 14.7 | 1.374 |
| | NY | | 1957–76 | | 66.9 | 16.6 | 1.468 |
| MA | NJ | 1967–74 | 1952–57 | 75.3 | 64.0 | 11.2 | 1.033 |
| | NJ | | 1963–76 | | 68.8 | 6.5 | 0.980 |
| | NY | | 1957–76 | | 65.3 | 9.9 | 1.332[†] |
| | DE | | 1960–65 | | 68.7 | 6.5 | 0.624[†] |
| | MD | | 1967–73 | | 70.1 | 5.1 | 0.727 |
| NJ | NY | 1952–57 | 1957–76 | 64.0 | 66.9 | –2.9 | –0.308 |
| | NC | | 1962–72 | | 68.5 | –4.5 | –0.501 |
| | VA | | 1965–72 | | 68.8 | –4.8 | –0.432 |
| NJ | NY | 1963–76 | 1957–76 | 68.8 | 66.9 | 1.9 | 0.474 |
| | NC | | 1962–72 | | 68.5 | 0.3 | 0.104 |
| | VA | | 1965–72 | | 68.8 | 0.1 | 0.002 |
| DE | MD | 1960–65 | 1967–73 | 72.8 | 70.1 | 2.7 | 0.317 |
| | NJ | | 1952–57 | | 64.0 | 8.8 | 0.739 |
| | NJ | | 1963–76 | | 68.8 | 4.0 | 0.486 |
| | NY | | 1957–76 | | 66.9 | 5.9 | 0.652 |
| | NC | | 1962–72 | | 68.5 | 4.3 | 0.503 |
| | VA | | 1965–72 | | 68.8 | 4.1 | 0.380 |
| MD | NJ | 1967–73 | 1952–57 | 70.1 | 64.0 | 6.1 | 0.671 |
| | NJ | | 1963–76 | | 68.8 | 1.3 | 0.428 |
| | NY | | 1957–75 | | 66.9 | 3.2 | 0.674 |
| | NC | | 1962–72 | | 68.5 | 1.6 | 0.427 |
| | VA | | 1965–72 | | 68.8 | 1.4 | 0.183 |
| NY | NC | 1957–76 | 1962–72 | 66.9 | 68.5 | –1.6 | –0.354 |
| | VA | | 1965–72 | | 68.8 | 4.7 | 0.965 |
| NC | VA | 1962–72 | 1965–72 | 68.5 | 68.8 | –0.3 | –0.037 |
| MI | NY | 1967–69 | 1957–76 | 68.9 | 66.9 | 2.0 | 0.380 |
| | OH | | 1969–74 | | 67.7 | –1.2 | 0.123 |
| | TN | | 1963–72 | | 71.8 | –2.9 | –0.605 |
| IL | MI | 1969–72 | 1967–69 | 67.2 | 68.9 | –1.7 | –0.315 |
| | OH | | 1969–74 | | 67.7 | –0.5 | –0.051 |
| | TN | | 1963–72 | | 71.8 | 4.6 | 0.279 |
| OH | TN | 1969–74 | 1963–72 | 67.7 | 71.8 | –2.5 | –2.540** |

**$\alpha < 0.05$.
[†]Annual survival rate estimate in excess of 1.00 was reduced to 0.99 to accommodate $z$ test statistic computer program.

Table K8. *Results of testing the hypothesis that adult female black duck survival rates are the same in various states (winter bandings).*

| Reference areas | vs. | Year comparisons | vs. | Mean survival rate comparisons | vs. | Difference | Test statistic $z$ value |
|---|---|---|---|---|---|---|---|
| ME | MA | 1960–62 | 1963–76 | 74.2 | 59.8 | 14.4 | 0.680 |
| | NJ | | 1965–76 | | 60.9 | 13.3 | 0.647 |
| | NY | | 1959–61 | | 50.5 | 23.7 | 1.146 |
| | NY | | 1963–72 | | 55.2 | 19.0 | 0.924 |
| | NC | | 1963–72 | | 50.6 | 26.5 | 1.077 |
| MA | NJ | 1963–76 | 1965–76 | 59.8 | 60.9 | –1.1 | –0.192 |
| | NY | | 1959–61 | | 50.5 | 9.3 | 1.421 |
| | NY | | 1963–72 | | 55.2 | 4.6 | 0.756 |
| | DE | | 1962–65 | | 63.4 | –3.7 | –0.321 |
| | MD | | 1957–63 | | 59.3 | 0.4 | 0.070 |
| NJ | NY | 1965–76 | 1959–61 | 60.9 | 50.5 | 10.4 | 2.745*** |
| | NY | | 1963–72 | | 55.2 | 5.7 | 1.988** |
| | NC | | 1963–72 | | 50.6 | 10.3 | 1.270 |
| | VA | | 1965–71 | | 67.7 | –6.8 | –2.051** |
| DE | MD | 1962–65 | 1957–63 | 63.4 | 59.3 | 4.1 | 0.396 |
| | MD | | 1967–73 | | 54.4 | 9.0 | 0.854 |
| | NJ | | 1965–76 | | 60.9 | 2.5 | 0.250 |
| | NY | | 1959–61 | | 50.5 | 12.9 | 1.236 |
| | NY | | 1963–72 | | 55.2 | 8.3 | 0.810 |
| | NC | | 1963–72 | | 50.6 | 12.8 | 1.010 |
| | VA | | 1965–71 | | 67.7 | –4.3 | –0.412 |
| MD | NJ | 1957–63 | 1965–76 | 59.3 | 60.9 | –1.6 | –0.445 |
| | NY | | 1959–61 | | 50.5 | 8.9 | 1.975** |
| | NY | | 1963–72 | | 55.2 | 8.7 | 1.031 |
| | NC | | 1963–72 | | 50.6 | 3.6 | 0.855 |
| | VA | | 1965–71 | | 67.7 | –8.4 | –2.064** |
| MD | NJ | 1967–73 | 1965–76 | 54.4 | 60.9 | –6.5 | –1.645* |
| | NY | | 1959–61 | | 50.5 | 4.0 | 0.832 |
| | NY | | 1963–72 | | 55.2 | –0.8 | –0.184 |
| MD | NC | 1967–73 | 1963–72 | 54.4 | 50.6 | 3.8 | 0.445 |
| | VA | | 1965–71 | | 67.7 | –13.3 | –3.025*** |
| NY | NC | 1959–61 | 1963–72 | 50.5 | 50.6 | –0.1 | –0.016 |
| | VA | | 1965–71 | | 67.7 | –17.2 | –4.037*** |
| NY | NC | 1963–72 | 1963–72 | 55.2 | 50.6 | 4.6 | 0.560 |
| | VA | | 1965–71 | | 67.7 | –12.5 | –3.606*** |
| NC | VA | 1963–72 | 1965–71 | 50.6 | 67.7 | –17.1 | –2.050*** |
| IL | OH | 1969–72 | 1971–74 | 59.5 | 48.1 | 11.4 | 1.309 |
| | TN | | 1963–72 | | 59.5 | –0.0 | –0.011 |

$^*\alpha < 0.1$; $^{**}\alpha < 0.05$; $^{***}\alpha < 0.01$.

Table K9. *Results of testing the hypothesis that adult male black duck survival rates are the same in variuos major reference areas (winter bandings).*

| Reference area comparisons | vs. | Year comparisons | vs. | Mean survival rate comparisons | vs. | Difference | Test statistic $z$ value |
|---|---|---|---|---|---|---|---|
| Maritimes (01) | Maine (02) | 1971-75 | 1960-63 | 55.4 | 83.5 | –28.1 | –1.789* |
| | S New Eng (03) | | 1972–76 | | 58.2 | 2.8 | –1.0221 |
| | LI–Hudson R (04) | | 1957–59 | | 73.8 | –18.4 | –1.308 |
| | Mid-Atl (05) | | 1952–56 | | 63.0 | –7.6 | –0.834 |
| | Mid-Atl (05) | | 1957–76 | | 67.5 | –12.1 | –1.042 |
| | Mid-Atl C (06) | | 1952–55 | | 68.4 | –13.0 | –0.927 |
| | Mid-Atl C (06) | | 1959–76 | | 67.6 | –12.2 | –1.057 |
| Maine (02) | S New Eng (03) | 1960–63 | 1972–76 | 83.5 | 58.2 | 25.3 | 2.101** |
| | LI–Hudson R (04) | | 1957–59 | | 73.8 | 9.7 | 0.729 |
| | Mid-Atl (05) | | 1952–56 | | 63.0 | 20.5 | 1.841* |
| | Mid-Atl (05) | | 1957–76 | | 67.5 | 16.0 | 1.501 |
| | Mid-Atl C (06) | | 1952–55 | | 68.4 | 15.1 | 1.131 |
| | Mid-Atl C (06) | | 1959–76 | | 67.6 | 15.9 | 1.485 |
| S New Eng (03) | LI–Hudson R (04) | 1972–76 | 1957–59 | 58.2 | 73.8 | 15.6 | –1.591 |
| | Mid-Atl (05) | | 1952–56 | | 63.0 | –4.8 | –0.738 |
| | Mid-Atl (05) | | 1957–76 | | 67.5 | –9.2 | –1.631 |
| | Mid-Atl C (06) | | 1952–55 | | 68.4 | –10.2 | –1.043 |
| | Mid-Atl C (06) | | 1959–76 | | 63.3 | –5.1 | –0.893 |
| LI–Hudson R (04) | Mid-Atl (05) | 1957–59 | 1952–56 | 73.8 | 63.0 | 10.8 | 1.246 |
| | Mid-Atl (05) | | 1957–76 | | 67.5 | 6.3 | 0.783 |
| | Mid-Atl C (06) | | 1952–55 | | 68.4 | 5.4 | 0.473 |
| | Mid-Atl C (06) | | 1959–76 | | 67.6 | 6.2 | 0.762 |
| | Lake Ont (08) | | 1956–58 | | 65.0 | 8.8 | 0.691 |
| | Lake Ont (08) | | 1963–74 | | 62.9 | –10.9 | 1.151 |
| Mid-Atl (05) | Mid-Atl C (06) | 1952–56 | 1952–55 | 63.0 | 68.4 | –5.4 | –0.627 |
| | Mid-Atl C (06) | | 1959–76 | | 67.6 | –4.6 | –1.372 |
| | Lake Ont (08) | | 1956–58 | | 65.0 | –2.0 | –0.194 |
| | Lake Ont (08) | | 1963–74 | | 62.9 | 0.1 | 0.024 |
| Mid-Atl (05) | Lake Erie (09) | 1952–56 | 1968–72 | 63.0 | 64.0 | –1.0 | –0.204 |
| Mid-Atl (05) | Mid-Atl C (06) | 1957–76 | 1952–55 | 67.5 | 68.4 | –1.0 | –0.119 |
| | Mid-Atl C (06) | | 1959–76 | | 67.6 | –0.2 | –0.134 |
| | Lake Ont (08) | | 1956–58 | | 65.0 | 2.5 | 0.248 |
| | Lake Ont (08) | | 1963–74 | | 62.9 | 4.6 | 0.895 |
| | Lake Erie (09) | | 1968–72 | | 64.0 | 3.5 | 0.957 |
| Mid-Atl C (06) | Lake Ont (08) | 1952–55 | 1956–58 | 68.4 | 65.0 | 3.4 | 0.269 |
| | Lake Ont (08) | | 1963–74 | | 62.9 | 5.6 | 0.587 |
| | Lake Erie (09) | | 1968–72 | | 64.0 | 4.4 | 0.507 |
| Mid-Atl C (06) | Lake Ont (08) | 1959–76 | 1956–58 | 67.6 | 65.0 | 2.6 | 0.265 |
| | Lake Ont (08) | | 1963–74 | | 62.9 | 4.8 | 0.927 |
| | Lake Erie (09) | | 1968–72 | | 64.0 | 3.7 | 1.001 |
| Lake Ont (08) | Lake Erie (09) | 1956–58 | 1968–72 | 65.0 | 64.0 | 1.0 | 0.099 |
| | Tenn R (11) | | 1963–71 | | 68.5 | –3.5 | –0.350 |
| Lake Ont (08) | Lake Erie (09) | 1963–74 | 1968–72 | 62.9 | 64.0 | –1.1 | –0.182 |
| | Tenn R (11) | | 1963–71 | | 68.5 | –5.6 | –1.074 |
| Lake Erie (09) | Tenn R (11) | 1968–72 | 1963–71 | 64.0 | 68.5 | –4.5 | –1.195 |
| | Lake Mich (12) | | 1967–69 | | 68.7 | –4.7 | –1.062 |
| | Lake Mich (12) | | 1972–74 | | 67.7 | –3.7 | –0.530 |
| | Up Miss R (13) | | 1964–72 | | 70.9 | –6.9 | –1.828* |
| Tenn R (11) | Lake Mich (12) | 1963–71 | 1967–69 | 68.5 | 68.7 | –0.2 | –0.079 |

Table K9. *Continued.*

| Reference area comparisons vs. | | Year comparisons vs. | | Mean survival rate comparisons vs. | | Difference | Test statistic z value |
|---|---|---|---|---|---|---|---|
| | Lake Mich (12) | | 1972–74 | | 67.7 | 0.8 | 0.124 |
| | Up Miss R (13) | | 1964–72 | | 70.9 | –2.4 | –1.281 |
| Lake Mich (12) | UP Miss R (13) | 1967–69 | 1964–72 | 68.7 | 70.9 | –2.2 | –0.713 |
| Lake Mich (12) | Up Miss R (13) | 1972–74 | 1964–72 | 67.7 | 70.9 | –3.2 | –0.510 |

$^*\alpha < 0.1$; $^{**}\alpha < 0.05$.

Table K10. *Results of testing the hypothesis that adult female black duck survival rates are the same in various major reference areas (winter bandings).*

| Reference area comparisons vs. | | Year comparisons vs. | | Mean survival rate comparisons vs. | | Difference | Test statistic z value |
|---|---|---|---|---|---|---|---|
| Maine (02) | S New Eng (03) | 1960–62 | 1939–42 | 74.2 | 48.4 | 25.8 | 1.150 |
| | S New Eng (03) | | 1963–76 | | 60.2 | 14.0 | 0.665 |
| | Mid-Atl (05) | | 1964–73 | | 60.0 | 14.1 | 0.675 |
| | Mid-Atl C (06) | | 1960–76 | | 61.6 | 12.6 | 0.603 |
| S New Eng (03) | Mid-Atl (05) | 1939–42 | 1964–73 | 48.4 | 60.0 | –11.6 | –1.119 |
| | Mid-Atl C (06) | | 1960–76 | | 61.6 | –13.1 | –1.071 |
| S New Eng (03) | Mid-Atl (05) | 1963–76 | 1964–73 | 60.2 | 60.0 | –0.1 | 0.018 |
| | Mid-Atl C (06) | | 1960–76 | | 61.6 | –1.4 | –0.200 |
| Tenn R (11) | Up Miss R (13) | 1963–71 | 1964–72 | 63.4 | 55.3 | 8.2 | 1.048 |

Table K11. *Results of testing the hypothesis that adult male black duck survival rates are the same in various minor reference areas (winter bandings).*

| Reference area comparisons | | Year comparisons | | Mean survival rate comparisons | | | Test statistic |
|---|---|---|---|---|---|---|---|
| | vs. | | vs. | Difference | z value | | |
| ME (021) | NH (031) | 1960–63 | 1966–68 | 83.5 | 60.4 | 23.1 | 1.482 |
| | MA (032) | | 1939–42 | | 77.2 | 6.3 | 0.496 |
| | | | 1969–76 | | 80.7 | 2.8 | 0.175 |
| | NY (042) | | 1957–59 | | 69.9 | 13.6 | 2.037* |
| | VA (051) | | 1966–72 | | 78.4 | 5.1 | 1.021 |
| | NC (052) | | 1962–72 | | 69.5 | 14.0 | 0.375 |
| | DE (053) | | 1963–75 | | 68.5 | 15.0 | 1.282 |
| | MD (055) | | 1961–63 | | 71.3 | 12.2 | 1.334 |
| | | | 1967–73 | | 69.0 | 14.5 | 1.313 |
| | NJ (063) | | 1952–55 | | 63.5 | 20.0 | 1.789* |
| | | | 1959–61 | | 73.5 | 10.1 | 0.583 |
| | | | 1963–76 | | 69.2 | 14.3 | 1.337 |
| | VA (064) | | 1965–68 | | 77.1 | 6.4 | 0.555 |
| NH (031) | MA (032) | 1966–68 | 1939–42 | 60.4 | 77.2 | –16.8 | –1.267 |
| | | | 1969–76 | | 80.7 | –20.3 | –1.243 |
| | NY (042) | | 1957–59 | | 69.9 | –9.5 | –0.681 |
| | VA (051) | | 1966–72 | | 78.4 | –17.0 | –1.257 |
| | NC (052) | | 1962–72 | | 69.5 | –9.1 | –0.782 |
| | DE (053) | | 1963–65 | | 68.5 | –8.0 | –0.672 |
| | MD (055) | | 1961–63 | | 71.3 | –10.9 | –0.703 |
| | | | 1967–73 | | 69.0 | –8.6 | –0.727 |
| | NJ (063) | | 1952–55 | | 63.5 | –3.1 | –0.259 |
| | | | 1959–61 | | 73.5 | –13.0 | –0.748 |
| | | | 1963–76 | | 69.2 | –8.8 | –0.766 |
| | VA (064) | | 1965–68 | | 77.1 | –16.6 | –1.359 |
| MA (032) | NY (042) | 1969–76 | 1957–59 | 80.7 | 69.9 | 10.8 | 0.763 |
| | VA (051) | | 1966–72 | | 78.4 | 2.4 | 0.163 |
| | NC (052) | | 1962–72 | | 69.5 | 11.2 | 0.936 |
| | DE (053) | | 1963–65 | | 68.5 | 12.3 | 0.997 |
| | MD (055) | | 1961–63 | | 71.3 | 9.4 | 0.600 |
| | | | 1967–73 | | 69.0 | 11.8 | 0.971 |
| | NJ (063) | | 1952–55 | | 63.5 | 17.2 | 1.410 |
| | | | 1959–61 | | 73.5 | 7.3 | 0.412 |
| | | | 1963–76 | | 69.2 | 11.6 | 0.979 |
| | VA (064) | | 1965–68 | | 77.1 | 3.7 | 0.291 |
| NY (042) | VA (051) | 1957–59 | 1966–72 | 69.9 | 78.4 | –8.5 | –0.719 |
| | NC (052) | | 1956–58 | | 69.5 | 0.4 | 0.045 |
| | DE (053) | | 1963–65 | | 68.5 | 1.4 | 0.162 |
| | MD (055) | | 1961–63 | | 71.3 | –1.4 | –0.106 |
| | | | 1967–73 | | 69.0 | 0.9 | 0.107 |
| | NJ (063) | | 1952–55 | | 63.5 | 6.4 | 0.734 |
| | | | 1959–61 | | 73.5 | –3.6 | –0.230 |
| | | | 1963–76 | | 69.2 | 0.7 | 0.088 |
| | VA (064) | | 1965–68 | | 77.1 | –7.2 | –0.775 |
| | NY (081) | | 1956–58 | | 65.0 | 4.9 | 0.392 |
| | | | 1964–74 | | 63.2 | 6.7 | 0.691 |
| VA (051) | NC (051) | 1966–72 | 1962–67 | 78.4 | 69.5 | 8.9 | 0.987 |
| | DE (053) | | 1963–65 | | 68.5 | 9.9 | 1.053 |
| | MD (055) | | 1961–63 | | 71.3 | 7.1 | 0.521 |

Table K11. *Continued.*

| Reference area comparisons | | Year comparisons | | Mean survival rate comparisons | | | Test statistic |
|---|---|---|---|---|---|---|---|
| | vs. | | vs. | Difference | z value | | |
| | | | 1967–73 | | 69.0 | 9.4 | 1.027 |
| | NJ (063) | | 1952–55 | | 63.5 | 14.9 | 1.601 |
| | | | 1959–61 | | 73.5 | 4.9 | 0.311 |
| | | | 1963–76 | | 69.2 | 9.2 | 1.053 |
| | VA (064) | | 1965–68 | | 77.1 | 1.3 | 0.133 |
| | NY (081) | | 1956–58 | | 65.0 | 13.3 | 1.040 |
| | | | 1964–74 | | 63.2 | 15.2 | 1.486 |
| NC (052) | DE (053) | 1962–72 | 1963–65 | 69.5 | 68.5 | 1.1 | 0.237 |
| | MD (055) | | 1961–63 | | 71.3 | –1.8 | –0.165 |
| | | | 1967–73 | | 69.0 | 0.5 | 0.140 |
| | NJ (063) | | 1952–55 | | 63.5 | 6.0 | 1.434 |
| | | | 1959–61 | | 73.5 | –3.9 | –0.293 |
| | | | 1963–76 | | 69.2 | 0.3 | 0.122 |
| | VA (064) | | 1965–68 | | 77.1 | –7.6 | –1.448 |
| | NY (081) | | 1956–58 | | 65.0 | 4.5 | 0.459 |
| | | | 1964–74 | | 63.2 | 5.5 | 1.265 |
| DE (053) | MD (055) | 1963–65 | 1961–63 | 68.5 | 71.3 | –2.8 | –0.254 |
| | | | 1967–73 | | 69.0 | –0.5 | –0.106 |
| | NJ (063) | | 1952–55 | | 63.5 | 5.0 | 0.982 |
| | | | 1959–61 | | 73.5 | –5.0 | –0.364 |
| | | | 1963–76 | | 69.2 | –0.7 | –0.184 |
| | VA (064) | | 1965–68 | | 77.1 | –8.6 | –1.450 |
| | NY (081) | | 1956–58 | | 65.0 | 3.5 | 0.861 |
| | | | 1964–74 | | 63.2 | 5.3 | 0.799 |
| MD (055) | NJ (063) | 1961–63 | 1952–55 | 71.3 | 63.5 | 7.8 | 0.707 |
| | | | 1959–61 | | 73.5 | –2.2 | –0.128 |
| | | | 1963–76 | | 69.5 | 2.1 | 0.200 |
| | VA (064) | | 1965–68 | | 77.1 | –5.8 | –0.503 |
| | NY (081) | | 1956–58 | | 65.0 | 7.3 | 0.658 |
| | | | 1964–74 | | 63.2 | 8.1 | 0.686 |
| MD (055) | NJ (063) | 1967–73 | 1952–55 | 69.0 | 63.5 | 5.5 | 1.199 |
| | | | 1959–61 | | 73.5 | –4.5 | –0.331 |
| | | | 1963–76 | | 69.2 | –0.2 | –0.065 |
| | NC (052) | | 1965–68 | | 77.1 | –8.1 | –1.466 |
| | NY (081) | | 1956–58 | | 65.0 | 4.5 | 1.055 |
| | | | 1964–74 | | 63.2 | 5.8 | 0.927 |
| NJ (063) | VA (064) | 1952–55 | 1965–68 | 63.5 | 77.1 | –13.6 | –2.358* |
| | NY (081) | | 1956–58 | | 65.0 | –1.5 | –0.152 |
| | | | 1964–74 | | 63.2 | 0.3 | 0.048 |
| NJ (063) | VA (064) | 1959–61 | 1965–68 | 73.5 | 77.1 | –3.6 | –0.258 |
| | NY (081) | | 1956–58 | | 65.0 | 8.5 | 0.691 |
| | | | 1964–74 | | 63.2 | 10.3 | 0.718 |
| NJ (063) | VA (064) | 1963–76 | 1965–68 | 69.2 | 77.1 | –7.9 | –1.650* |
| | NY (081) | | 1956–58 | | 65.1 | 4.2 | 1.356 |
| | | | 1964–74 | | 63.2 | 6.0 | 1.072 |
| VA (064) | NY (081) | 1965–68 | 1956–58 | | 65.0 | 4.2 | 1.142 |
| | | | 1964–74 | | 63.2 | 6.0 | 1.939* |
| NY (081) | IL (131) | 1956–58 | 1969–72 | 65.0 | 67.2 | –2.2 | –0.217 |
| | TN (113) | | 1963–71 | | 67.8 | –2.8 | –0.260 |
| | TN (133) | | 1964–72 | | 72.8 | –7.8 | –0.803 |
| NY (081) | IL (131) | 1964–74 | 1969–72 | 63.2 | 67.2 | –4.1 | –0.607 |

Table K11. *Continued.*

| Reference area comparisons | vs. | Year comparisons | vs. | Mean survival rate comparisons | | | Test statistic |
|---|---|---|---|---|---|---|---|
| | | | | Difference | $z$ value | | |
| | TN (113) | | 1963–71 | | 67.8 | –4.7 | –0.617 |
| | TN (133) | | 1964–72 | | 72.8 | –9.6 | –1.668* |
| TN (113) | IL (131) | 1963–71 | 1969–72 | 67.8 | 67.2 | 0.6 | 0.091 |
| | TN (133) | | 1964–72 | | 72.8 | –4.9 | –0.899 |
| | MI (123) | | 1967–73 | | 68.7 | –0.9 | –0.144 |
| TN (133) | IL (131) | 1964–72 | 1969–72 | 72.8 | 67.2 | 5.5 | 1.301 |
| MI (123) | IL (131) | 1967–73 | 1969–72 | 68.7 | 67.2 | 1.5 | 0.290 |
| | TN (133) | | 1964–72 | | 72.8 | –4.1 | –1.068 |

*$\alpha < 0.1$.

Table K12. *Results of testing the hypothesis that adult female black duck survival rates are the same in various minor reference areas (winter bandings).*

| Reference area comparisons | vs. | Year comparisons | vs. | Mean survival rate comparisons | vs. | Difference | Test statistic $z$ value |
|---|---|---|---|---|---|---|---|
| ME (021) | MA (032) | 1960–62 | 1963–72 | 74.2 | 62.7 | 11.6 | 0.546 |
| | | | 1974–76 | | 49.5 | 24.7 | 1.070 |
| | NY (036) | | 1959–61 | | 49.6 | 24.6 | 1.119 |
| | | | 1963–70 | | 57.9 | 16.3 | 0.787 |
| | VA (051) | | 1966–71 | | 66.0 | 8.1 | 0.394 |
| | NC (052) | | 1963–72 | | 53.9 | 20.3 | 0.982 |
| | MD (055) | | 1957–63 | | 59.3 | 14.8 | 0.719 |
| | | | 1967–69 | | 45.5 | 28.7 | 1.341 |
| | | | 1971–73 | | 62.7 | 11.4 | 0.541 |
| | NJ (063) | | 1965–76 | | 60.2 | 14.0 | 0.683 |
| MA (032) | NY (036) | 1963–72 | 1959–61 | 62.7 | 49.6 | 13.0 | 1.286 |
| | | | 1963–70 | | 57.9 | 4.7 | 0.684 |
| | VA (051) | | 1966–71 | | 66.0 | –3.5 | –0.504 |
| | NC (052) | | 1963–72 | | 53.9 | 8.7 | 1.268 |
| | MD (055) | | 1957–63 | | 59.3 | 3.2 | 0.485 |
| | | | 1967–69 | | 45.5 | 17.1 | 1.950* |
| | | | 1971–73 | | 62.7 | 0.2 | –0.022 |
| | NJ (063) | | 1965–76 | | 61.0 | 1.6 | 0.250 |
| MA (032) | NY (036) | 1974–76 | 1959–61 | 49.5 | 49.6 | –0.1 | –0.009 |
| | | | 1963–70 | | 57.9 | –8.4 | –0.745 |
| | VA (051) | | 1966–71 | | 66.0 | –16.6 | –1.460 |
| | NC (052) | | 1963–72 | | 53.9 | –4.4 | –0.387 |
| | MD (055) | | 1957–63 | | 59.3 | –9.9 | –0.878 |
| | | | 1967–69 | | 45.5 | 4.0 | 0.317 |
| | | | 1971–73 | | 62.7 | –13.3 | –1.100 |
| | NJ (063) | | 1965–76 | | 61.0 | –11.6 | –1.050 |
| NY (036) | VA (051) | 1959–61 | 1966–71 | 49.6 | 66.0 | –16.5 | –1.860* |
| | NC (052) | | 1963–72 | | 53.9 | –4.3 | –0.484 |
| | MD (055) | | 1957–63 | | 59.3 | –9.8 | –1.120 |
| | | | 1967–69 | | 45.5 | 4.1 | 0.394 |
| NY (036) | MD (055) | 1959–61 | 1971–73 | 49.6 | 62.7 | –13.2 | –1.350 |
| | NJ (063) | | 1965–76 | | 61.0 | –1.4 | –1.364 |
| NY (036) | VA (051) | 1963–70 | 1966–71 | 57.9 | 66.0 | –8.1 | –1.706* |
| | NC (052) | | 1963–72 | | 53.9 | 4.0 | 0.845 |
| | MD (055) | | 1957–63 | | 59.3 | –1.4 | –0.317 |
| | | | 1967–69 | | 45.5 | 12.4 | 1.715* |
| | | | 1971–73 | | 62.7 | –4.9 | –0.769 |
| | NJ (063) | | 1965–76 | | 61.0 | –3.1 | –0.809 |
| VA (051) | NC (052) | 1966–71 | 1963–72 | 66.0 | 53.9 | 12.2 | 2.524* |
| | MD (055) | | 1957–63 | | 59.3 | 6.7 | 1.471 |
| | | | 1967–69 | | 45.5 | 20.6 | 2.827** |
| | | | 1971–73 | | 62.7 | 3.3 | 0.517 |
| | NJ (063) | | 1965–76 | | 61.0 | 5.0 | 1.289 |
| NC (052) | MD (055) | 1963–72 | 1957–63 | 55.7 | 59.3 | –3.6 | –0.855 |
| | | | 1967–79 | | 45.5 | 10.2 | 1.447 |
| | | | 1971–73 | | 62.7 | –7.0 | –1.151 |
| | NJ (063) | | 1965–76 | | 61.0 | –5.3 | –1.294 |
| MD (055) | NJ (063) | 1957–63 | 1965–76 | 59.3 | 61.0 | –1.7 | –0.470 |
| | | 1967–69 | 1965–76 | 45.5 | 61.0 | –15.5 | –2.318* |

Table K12. *Continued.*

| Reference area comparisons vs. | | Year comparisons vs. | | Mean survival rate comparisons vs. | | Difference | Test statistic $z$ value |
|---|---|---|---|---|---|---|---|
| | | 1971–73 | 1965–76 | 62.7 | 61.0 | 1.7 | 0.306 |
| TN (113) | IL (131) | | 1969–72 | 60.0 | 59.5 | 0.5 | 0.125 |
| | TN (133) | | 1965–72 | | 59.0 | 1.0 | 0.266 |
| IL (131) | TN (133) | | 1965–72 | 59.5 | 59.0 | 0.5 | 0.132 |

*$\alpha < 0.1$; **$\alpha < 0.05$.

# Appendix L. An Example of the Stochastic Model Output: Continental Black Duck Population.

WEIGHTED AVERAGE ANNUAL SURVIVAL RATES AND AGE RATIO

```
************** INPUTS **************
 0.6134 0.5284 0.4260 0.4127
 1.1472 0.0023
   50000.   50000.
   50
 0.0195 0.0028 0.0048 0.0011
 0.0028 0.0255 0.0092 0.0235
 0.0048 0.0092 0.0122 0.0087
 0.0011 0.0235 0.0087 0.0264
 0.5000
************************************
```

| YR | POPULATION SIZE A-M | A-F | YNG | TOTAL | CHNGE | SURVIVAL RATES A-M | A-F | Y-M | Y-F | SEX RATIO | AGE RATIO |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 50000. | 50000. | 114720. | 214720. | 0.0 | 0.6134 | 0.5284 | 0.4260 | 0.4127 | 0.5000 | 1.1672 |
| 2 | 47699. | 30182. | 91176. | 169057. | 0.7873 | 0.5384 | 0.5384 | 0.5047 | 0.4011 | 0.6125 | 1.1707 |
| 3 | 48688. | 34533. | 94280. | 177502. | 1.0500 | 0.4262 | 0.7082 | 0.3560 | 0.4964 | 0.5850 | 1.1329 |
| 4 | 37531. | 47857. | 97912. | 183300. | 1.0327 | 0.9337 | 0.5232 | 0.5518 | 0.3513 | 0.4395 | 1.1467 |
| 5 | 62060. | 42232. | 112442. | 216734. | 1.1824 | 0.6825 | 0.8476 | 0.4479 | 0.7313 | 0.5951 | 1.0781 |
| 6 | 67538. | 76914. | 171853. | 316305. | 1.4594 | 0.8053 | 0.6046 | 0.4389 | 0.5144 | 0.4675 | 1.1897 |
| 7 | 92104. | 90696. | 223715. | 406515. | 1.2852 | 0.7157 | 0.4491 | 0.5590 | 0.3691 | 0.5039 | 1.2238 |
| 8 | 128450. | 82020. | 253478. | 463948. | 1.1413 | 0.6121 | 1.0000* | 0.5946 | 0.8847 | 0.6103 | 1.2043 |
| 9 | 153985. | 194149. | 400521. | 748655. | 1.6137 | 0.7040 | 0.5285 | 0.3548 | 0.4527 | 0.4423 | 1.1505 |
| 10 | 179466. | 193266. | 428163. | 800895. | 1.0698 | 0.9126 | 0.4559 | 0.2925 | 0.3627 | 0.4815 | 1.1487 |
| 11 | 226412. | 165760. | 419484. | 811655. | 1.0134 | 0.5115 | 0.3403 | 0.3093 | 0.2464 | 0.5773 | 1.0696 |
| 12 | 180672. | 108086. | 322720. | 611478. | 0.7534 | 0.8489 | 0.4516 | 0.4764 | 0.3994 | 0.6257 | 1.1176 |
| 13 | 230244. | 113253. | 377362. | 720859. | 1.1789 | 0.5356 | 0.6493 | 0.4132 | 0.6063 | 0.6703 | 1.0986 |
| 14 | 201278. | 187924. | 434375. | 823577. | 1.1425 | 0.3989 | 0.5803 | 0.3927 | 0.4738 | 0.5172 | 1.1161 |
| 15 | 165570. | 211957. | 423091. | 800628. | 0.9721 | 0.4997 | 0.4378 | 0.3607 | 0.3066 | 0.4386 | 1.1207 |
| 16 | 159032. | 157497. | 348911. | 665440. | 0.8311 | 0.5813 | 0.4685 | 0.3962 | 0.4600 | 0.5024 | 1.1023 |
| 17 | 161567. | 152768. | 357776. | 672112. | 1.0100 | 0.7298 | 0.4893 | 0.3428 | 0.3509 | 0.5140 | 1.1382 |
| 18 | 179240. | 137513. | 346428. | 663180. | 0.9867 | 0.6574 | 0.5544 | 0.5087 | 0.3636 | 0.5659 | 1.0937 |
| 19 | 205958. | 139211. | 365064. | 710233. | 1.0709 | 0.6439 | 0.4732 | 0.4156 | 0.4313 | 0.5967 | 1.0576 |
| 20 | 208486. | 144586. | 403037. | 756108. | 1.0646 | 0.5556 | 0.5374 | 0.4766 | 0.4100 | 0.5905 | 1.1415 |
| 21 | 211873. | 160309. | 446436. | 818619. | 1.0827 | 0.4695 | 0.9530 | 0.6406 | 0.7716 | 0.5693 | 1.1995 |
| 22 | 242479. | 325009. | 703518. | 1271006. | 1.5526 | 0.3865 | 0.5610 | 0.4053 | 0.4809 | 0.4273 | 1.2397 |
| 23 | 236301. | 351486. | 667710. | 1255496. | 0.9578 | 0.6492 | 0.3901 | 0.4934 | 0.2505 | 0.4020 | 1.1360 |
| 24 | 318135. | 220752. | 631471. | 1170358. | 0.9322 | 0.5273 | 0.3915 | 0.3617 | 0.4046 | 0.5904 | 1.1718 |
| 25 | 281974. | 214185. | 532480. | 1028639. | 0.8789 | 0.5175 | 0.4331 | 0.3909 | 0.3285 | 0.5683 | 1.0732 |
| 26 | 249987. | 180240. | 468203. | 898431. | 0.8734 | 0.5383 | 0.5451 | 0.4427 | 0.4874 | 0.5811 | 1.0883 |
| 27 | 238223. | 212357. | 509449. | 960029. | 1.0686 | 0.5390 | 0.3785 | 0.3852 | 0.3155 | 0.5287 | 1.1306 |
| 28 | 226528. | 160748. | 444802. | 832078. | 0.8567 | 0.6299 | 0.7512 | 0.4713 | 0.6455 | 0.5849 | 1.1485 |
| 29 | 247520. | 264314. | 569832. | 1081665. | 1.3000 | 0.3338 | 0.4734 | 0.3722 | 0.4494 | 0.4836 | 1.1133 |
| 30 | 188674. | 253156. | 512242. | 954073. | 0.8820 | 0.7781 | 0.4071 | 0.4773 | 0.2622 | 0.4270 | 1.1594 |
| 31 | 269061. | 170220. | 501948. | 941229. | 0.9565 | 0.7845 | 0.7570 | 0.4738 | 0.5120 | 0.6125 | 1.1427 |
| 32 | 330007. | 257371. | 651985. | 1239363. | 1.3168 | 0.6500 | 0.6165 | 0.4703 | 0.5695 | 0.5618 | 1.1100 |
| 33 | 361202. | 344320. | 849604. | 1555126. | 1.2548 | 0.4430 | 0.4768 | 0.4374 | 0.3957 | 0.5120 | 1.2042 |
| 34 | 345835. | 332276. | 742000. | 1420112. | 0.9132 | 0.7895 | 0.6203 | 0.4503 | 0.5083 | 0.5100 | 1.0942 |
| 35 | 440105. | 394692. | 876636. | 1711432. | 1.2051 | 0.4549 | 0.2535 | 0.2616 | 0.1594 | 0.5272 | 1.0501 |
| 36 | 314857. | 169950. | 510471. | 995278. | 0.5815 | 0.6968 | 0.4543 | 0.4094 | 0.3302 | 0.6494 | 1.0529 |
| 37 | 323892. | 161491. | 555383. | 1040767. | 1.0457 | 0.4157 | 0.5191 | 0.3751 | 0.4820 | 0.6673 | 1.1442 |
| 38 | 238796. | 217665. | 491881. | 948342. | 0.9112 | 0.8392 | 0.7522 | 0.7687 | 0.7198 | 0.5231 | 1.0776 |
| 39 | 389437. | 340748. | 849893. | 1580078. | 1.6661 | 0.8155 | 0.2494 | 0.3102 | 0.1807 | 0.5333 | 1.1639 |
| 40 | 449418. | 161800. | 720080. | 1331298. | 0.8426 | 0.2531 | 0.4184 | 0.3152 | 0.4517 | 0.7353 | 1.1781 |
| 41 | 227241. | 230328. | 525725. | 983295. | 0.7386 | 0.4234 | 0.4329 | 0.2077 | 0.2711 | 0.4966 | 1.1490 |
| 42 | 150808. | 170968. | 384737. | 706513. | 0.7185 | 0.5388 | 0.5435 | 0.4178 | 0.3828 | 0.4687 | 1.1957 |
| 43 | 161628. | 166554. | 380467. | 708649. | 1.0030 | 0.4922 | 0.3619 | 0.3977 | 0.1724 | 0.4925 | 1.1593 |
| 44 | 155223. | 93073. | 285689. | 533985. | 0.7535 | 0.5935 | 0.6744 | 0.5757 | 0.4671 | 0.6252 | 1.1506 |
| 45 | 174361. | 129491. | 308829. | 612680. | 1.1474 | 0.4640 | 0.6261 | 0.4039 | 0.4724 | 0.5738 | 1.0164 |
| 46 | 143281. | 154013. | 346211. | 643505. | 1.0503 | 0.2912 | 0.7563 | 0.2616 | 0.5631 | 0.4820 | 1.1645 |
| 47 | 87010. | 213958. | 343046. | 644015. | 1.0008 | 0.7493 | 0.5447 | 0.4254 | 0.4627 | 0.2891 | 1.1398 |
| 48 | 138165. | 195912. | 363546. | 697623. | 1.0832 | 0.5798 | 0.4613 | 0.4010 | 0.4014 | 0.4136 | 1.0882 |
| 49 | 153001. | 163328. | 354392. | 670721. | 0.9614 | 0.6525 | 0.5043 | 0.2895 | 0.4438 | 0.4837 | 1.1203 |
| 50 | 151135. | 161010. | 332586. | 644731. | 0.9613 | 0.7903 | 0.5600 | 0.5181 | 0.5708 | 0.4842 | 1.0655 |

```
        POPULATION MEAN        816241.                 VARIANCE          0.1320D+12

        AVERAGE ADULT MALES        204643.        AVERAGE ADULT FEMALES=      178643.
        AVERAGE YOUNG MALES=        216478.        AVERAGE YOUNG FEMALES=      216478.

AVERAGE SURVIVAL RATES
  0.5991   0.5378   0.4223   0.4342

AVERAGE P(I)     1.1315 VAR OF P(I)  0.2314D-02

VAR-COV MATRIX
 0.2570D-01   0.3513D-03   0.6336D-02   0.1504D-03
 0.3513D-03   0.2453D-01   0.8717D-02   0.2180D-01
 0.6336D-02   0.8717D-02   0.1057D-01   0.8319D-02
 0.1504D-03   0.2180D-01   0.8319D-02   0.2318D-01

IX=            787751569  IY=          -409258603

MEAN SEX RATIO=     0.5328      VAR. OF MEAN SEX RATIO=     0.0066
MEAN RATE OF CHANGE=     1.0451      VAR. OF MEAN RATE OF   CHANGE=     0.0503
CHANGE=   1.02352
```

An example of the stochastic model output: Continental Black Duck Population.

# Appendix M. Individuals and Agencies That Have Banded More Than 100 Black Ducks Since 1918.

Table M1. *Individuals and agencies that have banded more than 100 black ducks since 1918 (all banding periods, all status codes).*

| Permittee | Number banded |
|---|---|
| NY Dept. Env. Cons. | 68,817 |
| MA Div. Fish & Wildl. | 27,639 |
| NJ Div. Fish Game & Shellfish | 25,455 |
| Parker River NWR | 22,163 |
| MI Dept. Nat. Res. | 19,629 |
| MD Wildl. Admin. | 18,737 |
| TN Wildl. Res. Agency | 14,658 |
| A. D. Smith | 14,548 |
| ME Dept. Inland Fish & Game | 14,388 |
| PA Game Comm. | 13,765 |
| IL Dept. Cons. | 12,392 |
| W. B. Large | 12,335 |
| ME Coop. Wildl. Res. Unit | 12,179 |
| Cross Creeks NWR | 11,446 |
| O. L. Austin | 10,577 |
| VT Fish & Game Dept. | 10,426 |
| OH Div. Wildl. | 10,402 |
| ON Ministry Nat. Res. | 9,447 |
| IN Dept. Nat. Res. | 8,464 |
| Seney NWR | 8,207 |
| E. D. Kroll | 8,058 |
| Kellogg Bird Sanctuary | 7,990 |
| W. R. Whitman | 7,650 |
| Bombay–Prime Hook NWR | 6,998 |
| NC Wildl. Res. Comm. | 6,312 |
| Brigantine NWR | 6,066 |
| DE Div. Fish & Wildl. | 6,007 |
| H. E. Greenward | 5,826 |
| D. E. Russ | 5,745 |
| CT Dept. Env. Protection Wildl. Unit | 5,380 |
| Moosehorn NWR | 5,324 |
| U.S. & Canadian Wildl. Serv. | 5,218 |
| J. Powers | 5,100 |
| A. Reed | 5,019 |
| Blackwater NWR | 4,949 |
| J. Jedlicka | 4,919 |
| Northeastern Wildl. Sta. | 4,802 |
| J. J. Storrow | 4,734 |
| AL Dept. Cons. | 4,527 |
| Eastern Neck NWR | 4,518 |
| J. A. Hagar | 4,447 |
| H. S. Osler | 4,261 |
| RI Div. Fish & Wildl. | 4,140 |
| Fish & Wildl. Div. | 4,088 |
| P. Dupuis | 4,027 |
| TN NWR | 3,995 |
| E. J. Baker | 3,913 |
| Montezuma NWR | 3,750 |
| A. Rotch | 3,676 |
| A. Bourget | 3,417 |
| M. H. Field | 3,413 |
| J. R. Morin, Min. Nat. Res. | 3,322 |
| Chincoteague NWR | 3,252 |
| Presquile NWR | 3,090 |
| Kemptville Dept. Lands & Forests | 3,085 |
| Pea Isl. NWR | 2,920 |
| C. R. Warren | 2,858 |
| H. Moore | 2,857 |
| W. Vogt | 2,640 |
| Mattamuskeet NWR | 2,612 |
| KY Dept. Fish & Wildl. Res. | 2,593 |
| WI Dept. Nat. Res. | 2,536 |
| B. W. Parker | 2,516 |
| M. Laperle | 2,496 |
| Chautauqua NWR | 2,441 |
| Back Bay NWR | 2,405 |
| VA Comm. Game & Inland Fish | 2,388 |
| R. O. Halstead | 2,317 |
| O. E. Seelye | 2,257 |
| P. C. Barney | 2,146 |
| Shiawassee NWR | 2,006 |
| IL Nat. Hist. Survey | 1,991 |
| R. Federico | 1,931 |
| Baie Johan Beetz Band Sta. | 1,801 |
| J. H. White | 1,697 |
| R. Parker | 1,602 |
| G. F. Boyer | 1,576 |
| D. G. Dennis | 1,558 |
| W. T. Munro | 1,551 |
| Santee NWR | 1,548 |
| A. Salvadori | 1,541 |
| Canadian Wildl. Serv. | 1,489 |
| A. T. Cringan | 1,456 |
| K. Christofferson | 1,453 |
| L. Brochet | 1,436 |
| C. O. Bartlet | 1,424 |

Table M1. *Continued.*

| Permittee | Number banded | Permittee | Number banded |
|---|---|---|---|
| J. H. Buckalew | 1,390 | L. Lemieux | 525 |
| C. J. Mercer | 1,360 | SC Wildl. & Marine Res. | 522 |
| Missisquoi NWR | 1,336 | E. H. Stone | 515 |
| Wheeler NWR | 1,319 | F. J. Gramlich | 509 |
| M. F. Hudson | 1,288 | J. D. Withers | 506 |
| Horicon NWR | 1,226 | Ducks Unlimited | 498 |
| W. E. Diffendall | 1,214 | MS Game & Fish Comm. | 492 |
| Crab Orchard NWR | 1,180 | Pungo NWR | 491 |
| Great Meadows NWR | 1,166 | Pee Dee NWR | 488 |
| G. Moisan | 1,163 | F. H. Folemsbee | 473 |
| T. Demarest | 1,163 | A. A. Allen | 460 |
| WV Dept. Nat. Res. | 1,116 | A. Devos | 457 |
| QU Reg. Off., CWS | 1,107 | T. N. Jones | 452 |
| Migratory Bird & |  | J. W. Perkins | 452 |
| Hab. Res. Lab. | 1,103 | Tweed, Min. Nat. Res. | 436 |
| Rice Lake NWR | 1,091 | Prince Edward Point Obs. | 435 |
| J. Hamilton Min. Nat. Res. | 1,068 | M. P. Harvey | 423 |
| W. Burding | 1,055 | J. Pulitzer | 422 |
| Nova Scotia Dept. Lands |  | NH Fish & Game Dept. | 420 |
| & Forests | 967 | Savannah NWR | 418 |
| H. W. Brown | 831 | Carolina Sandhills NWR | 405 |
| J. W. Van Weelden | 799 | OH Coop. Wildl. Res. Unit | 400 |
| Cape Romain NWR | 788 | J. J. Frey | 395 |
| L. H. Hutchens | 778 | P. Olin | 394 |
| Brookgreen Gardens | 774 | I. B. Earl | 392 |
| W. Guest | 760 | J. W. Sangster | 384 |
| L. H. Barkhausen | 745 | Agassiz NWR | 381 |
| F. B. McGilvrey | 719 | C. J. Goetz | 373 |
| E. C. Smith | 712 | R. Johanson | 349 |
| T. R. Gallo | 696 | G. J. Ross | 337 |
| J. A. Sumrell | 680 | Gananoque Dept. Lands & For. | 327 |
| White River NWR | 670 | Iroquois NWR | 319 |
| J. A. Macfie | 659 | F. Hopkins | 311 |
| C. A. Beckhart | 657 | P. F. Hodge | 307 |
| Morton NWR | 651 | Necedah NWR | 282 |
| R. R. Cook | 631 | C. D. Snow | 279 |
| KY Woodlands NWR | 605 | T. S. Hennessy | 272 |
| D. F. Blais | 601 | A. Allen | 264 |
| D. J. Gawley | 599 | Wapanocca NWR | 260 |
| MN Div. Fish & Wildl. | 581 | N. G. Perret | 248 |
| R. W. Fyfe | 572 | J. M. Taylor | 247 |
| Ottawa NWR | 561 | R. F. Coleman | 239 |
| L. S. Crandall | 558 | F. E. Ludwig | 237 |
| H. A. Bartholomew | 531 | S. T. Miller | 236 |
| J. W. Stack | 233 | Noxubee NWR | 111 |
| W. T. Miller | 231 | Target Rock NWR | 110 |
| Eufaula NWR | 229 | E. R. Jones | 109 |
| G. A. Bryan | 229 | J. Clark Salyer NWR | 107 |
| C. L. Hauthaway | 225 | M. H. Cecil | 106 |
| C. W. Collins | 225 | R. E. Dennis | 106 |
| H. H. Southam | 223 | D. D. McLean | 104 |
| L. J. Badger | 223 | LA Dept. Wildl. & Fisheries | 103 |

Table M1. *Continued.*

| Permittee | Number banded | Permittee | Number banded |
|---|---|---|---|
| S. Hall | 222 | Reelfoot NWR | 101 |
| J. J. Lynch | 219 | A. G. Pursley | 101 |
| I. S. Strugis | 216 | | |
| J. Tingley | 205 | | |
| MB Dept. Renew. Res. | 201 | | |
| J. K. Lowther | 200 | | |
| H. S. Turner | 195 | | |
| F. H. Leser | 187 | | |
| Mingo NWR | 175 | | |
| H. H. Krug | 173 | | |
| G. Garbutt | 173 | | |
| St. Marks NWR | 172 | | |
| D. Kirkland | 167 | | |
| Squaw Creek NWR | 162 | | |
| J. F. Anderson | 159 | | |
| OR Waterfowl Res. Found. | 159 | | |
| Upper Mississippi NWR | 156 | | |
| D. D. Davenport | 148 | | |
| R. A. Tubert | 148 | | |
| D. J. Hussell | 145 | | |
| G. E. Cummings | 143 | | |
| VA Coop. Wildl. Res. Unit | 136 | | |
| D. E. Story | 131 | | |
| J. R. Bailey, Min. Nat. Res. | 130 | | |
| R. W. Tippett, Min. Nat. Res. | 130 | | |
| A. S. Hawkins | 125 | | |
| R. D. Harris | 122 | | |
| H. P. Cottingham | 121 | | |
| R. F. Brace | 121 | | |
| C. Weinberger | 120 | | |
| R. W. Tufts | 119 | | |
| J. H. Rumney, Min. Nat. Res. | 119 | | |
| J. J. Blakemore | 118 | | |
| R. W. Fuller | 116 | | |
| W. R. Catton | 115 | | |
| W. L. McKinnon | 114 | | |

# Postscript

## A Retrospective Look at Warren Blandin's Thesis in the Light of Subsequent Research on American Black Ducks

## Introduction

This postscript begins with a brief personal note. When I arrived at the Migratory Bird and Habitat Research Laboratory (MBHRL) at Patuxent Wildlife Research Center (PWRC) in 1979, Ph.D. fresh in hand, one of my first assignments was to assist the Migratory Bird Management Office in an "update" of the analyses of black duck recoveries already performed by Warren Blandin which constituted the core of his Ph.D. thesis. I was also charged with performing analyses of the reward band study on black ducks, then nearing its completion under the tutelage of Warren. I had little experience or exposure to the field of waterfowl management, in particular to the details of banding study design, and the rationale for my involvement in these studies was my academic training in biometrics. It was thus critical that I quickly develop a close working relationship with a biologist expert in black duck biology, familiar with the intricacies of the Bird Banding Laboratory retrieval files, and who had a good understanding of the strengths and weaknesses of the data. There was never any question that Warren Blandin was that biologist, and I feel fortunate to have been able to work with him.

In writing this postscript, and reviewing the events that have passed since Warren's tragic, early death, I have been struck more than ever by how much the profession is indebted to Warren for his seminal work on black ducks. In these pages, I will share how Warren's work provided the best information available on management of black ducks in 1982, and that the principal results of Warren's work still stand. Perhaps more important, I will show that Warren framed many of the scientific questions we are still trying to answer today. I think that Warren's thesis anticipated and motivated much of the work on black duck population ecology in the ensuing decade.

My commentary follows the organization of the thesis itself. Where I compare specific results from Warren's thesis to results of subsequent studies, the intent is to show the relationship of the former to the latter rather than to critique either.

In his thesis, Warren comprehensively summarized previous work on black duck population ecology. Importantly, he was an advocate for the "modern" approach to inference using band recovery data (Brownie et al. 1985). His thesis was the first comprehensive analysis based on these methods. It also provided the best state of knowledge on black duck status at the time, and the immediate management needs of black duck populations, including those directed toward better operational surveys.

Finally, as previously mentioned, his thesis motivated further band recovery analyses, in particular: to address the effects of hunting, investigate the annual life-cycle of black ducks, and synthesize ideas on population dynamics.

## Blandin's Results in the Light of Subsequent Work

### *Band Recovery Analyses, Effect of Hunting on Survival*

At the time of his death Warren had been responsible for coordinating a comprehensive banding program to address questions of importance to black duck management. Perhaps the most notable of these, and one in which I assisted, was the reward-band study to estimate band reporting rates for black ducks shot and retrieved by hunters. This information was needed to adjust band recovery rates for the proportion of unreported bands, to provide accurate estimates of harvest rates. Warren incorporated preliminary estimates from the reward-band study in his estimates of harvest rates and proportion of mortality due to hunting (Blandin 1982). The estimates were not substantially different from those published posthumously (Conroy and Blandin 1984), although some of the final conclusions in Conroy and Blandin (1984) differ with respect to temporal and geographic patterns of variation in reporting rate.

In the years following Warren's death, there was a spate of research on patterns of variation in survival and recovery rates in black ducks, particularly ones that focused on the effects of hunting on survival. Boyd and Hyslop (1985) used band recovery analyses to conclude that there was no evidence of an effect of differing levels of harvest rate on survival. However, Conroy and Krementz (1986) showed that these analyses did not support the authors' contention, because of errors in statistical methodology. It is notable that these were errors of the type that Blandin (1982) was careful to avoid, i.e., the patterns observed were due to mathematical relations among the parameter estimates, rather than to the underlying population characteristics of interest.

Subsequent work in which I was involved dealt with detailed analyses to "update the recent estimates of survival and recovery rates by Blandin (1982)" (Krementz et al. 1987: 689) and to investigate temporal, geographic, and age- and sex-specific variation in these rates. The results of this study were similar to those of Blandin

(1982), although we found little evidence of sex-specific differences in adult recovery rates. Krementz et al. (1988a) specifically addressed the question of the effect of harvest rate on annual survival of black ducks, and reached conclusions similar to Blandin (1982) about the overall effect of hunting. The estimated proportion of mortality due to hunting was somewhat lower than that estimated by Blandin (1982), mostly because of differences in statistical methods, and in estimates used for band reporting rates. However, and more importantly, Krementz et al. (1988a), like Blandin (1982), found evidence for an additive effect of hunting on total mortality, at least for some components of the population, although neither Blandin nor we were satisfied that we had adequately tested the relation between hunting and total mortality. In particular, where compensation seemed to occur (i.e., when hunting mortality changes, the total survival stays about the same) there was no consistent suggestion of a mechanism (i.e., density-dependent mortality) for compensation (Blandin 1982; Conroy et al. 1989b; Conroy and Krementz 1990).

Another important study during this time was a comparison of survival and recovery rates of sympatric, wintering black ducks and mallards (Nichols et al. 1987). Interspecific differences in these rates had been suggested by Blandin (1982) and others as possible explanation for black duck declines. Nichols et al. (1987) found no evidence for differences in mortality, and suggested that observed lower population growth rates for black ducks could be best explained by differential reproduction or immigration. However, suggestions of additivity for some populations of black ducks (Blandin 1982; Krementz et al. 1988a) make it likely that at least some populations of black ducks respond differently to hunting pressure. Further, contemporary comparative data on survival and harvest rates for two harvested species are not helpful in determining what survival in the absence of hunting would have been without assuming the form of the relation between survival and hunting kill rates (Conroy and Krementz 1990).

## *Evaluation of Population Status*

Had Warren ended his thesis with the comprehensive band analyses described above, Blandin (1982) would have been a major contribution, and no doubt would have fulfilled the expectations of his graduate committee. We can be glad he did not stop there, but went on to integrate his estimates of survival rates with existing data on recruitment rates and population surveys. He used these data, together with deterministic and stochastic population models, to project population growth rates for black ducks. His analyses pointed to apparent inconsistencies in the data, in that projected growth rates were much higher than indicated by historical black duck surveys (which in fact indicated a slow decline). Warren suggested that these inconsistencies were likely due to poor estimates of reproduction rates based on age ratios, and that further work was needed to provide unbiased estimates of recruitment.

In my opinion, there has been little fundamental progress in this area since Blandin (1982). We use the same basic techniques for population projection, and the quality of the data (particularly reproduction rates) are little better than Warren had available. An "advance" of sorts is the development of a more detailed, mechanistic model for the life cycle of ducks (e.g. Johnson et al. 1988), although at present this model has little predictive value because so little is known about specific components of the life cycle. Some "new" ideas about additive and compensatory mortality in black ducks were presented by Conroy and Krementz (1990). Actually, these were more of a piecing together of ideas that have been around for a while, about partial compensation (e.g. Anderson and Burnham 1976; Caughley 1985), life history differences among anatids (Nudds 1983; Patterson 1979), and the importance of environmental variability (e.g. Conroy et al. 1989b).

A tentative sign of progress is the growing consensus that the question of the effects of hunting will not be answered until experiments directed toward that question are conducted (Anderson et al. 1987; Conroy and Krementz 1990); it remains to be seen whether the political will to conduct such experiments is forthcoming.

## *Management Recommendations*

One month before Warren's death, the Service had been embroiled in litigation, brought by anti-hunting elements, to stop hunting of black ducks on the argument that continuation of hunting was a violation of the Migratory Bird Treaty Act (MBTA) (Feierabend 1984). The judge ruled in the Service's favor, but the political and legal climate assured that proposed reductions of black duck kill in the U.S. and Canada would take place (Rogers and Patterson 1984). Blandin (1982), together with his expert testimony, was very important, first in demonstrating that the Service was acting responsibly and within MBTA, and second in providing sound rationale for the ensuing reduction in season lengths and bag limits (Rogers and Patterson 1984). Blandin (1982) also focused attention on efforts to gain improved information about black duck status, through cooperative banding and survey programs.

## *Recommendations for Further Research*

An important part of Blandin (1982) was the section in which Warren, using his years of experience and perspective in dealing with continental black duck issues, made specific recommendations for further research to advance our understanding of black duck population dynamics, and thus to improve our ability to manage the species. Warren's recommendations for further work fell into four broad categories, discussed below. While I do not claim that all subsequent research in these areas owes its origin to Blandin (1982), I think that Warren greatly influenced many who followed. This is particularly true for those of us who worked with him, or who were associated with MBHRL and PWRC.

The first area that Warren identified was the need for studies on the post-breeding habitat, movements, and survival of black ducks. Much work in this area was accomplished at the MBHRL/PWRC Maine Field Station (under the direction of J. R. Longcore) and the University of Maine, and has resulted in publications on the movement and survival of molting males (Bowman and Longcore 1989), and movements and habitat use (Frazer et al. 1990; a, b) and survival (Longcore et al. 1991) of post-fledgling black ducks. This research has begun to provide information previously lacking about an important portion of black duck life history.

Another research priority, identified in Blandin (1982), was the need for studies to determine time- and cause-specific winter mortality, and the role of food resources during winter. Work by Brodsky and Weatherhead (1985a,b) suggested that adequate food resources were important in enhancing courtship and other behaviors during periods of winter stress. During 1983–86 I coordinated the first large-scale study of time- and cause-specific mortality of wintering black ducks (Conroy et al. 1987; 1989b). One important finding of this work was an apparent association between early-winter body mass of female black ducks, and the subsequent probability of surviving winter (although subsequent analysis of capture-recapture records by Krementz et al. [1988b] failed to corroborate this pattern). Additional research, associated with this project, assessed specific aspects of food resource availability, physiological condition, and foraging patterns of wintering black ducks (Costanzo 1988; Morton et al. 1989, 1990).

It was clear to Warren that the ability to manage black duck populations was hampered by lack of accurate and precise population statistics. Thus, Blandin (1982) contains a major recommendation that effort be expended in the design of statistically valid surveys to estimate winter populations, the size and rate of the harvest, and reproduction rates. Progress was made in the first of these in the application of a statistically-based transect survey to winter population estimates (Conroy et al. 1988). Work is still needed in improving precision and accuracy of harvest species for all ducks (Geissler 1990). Efforts are underway, under the auspices of the Black Duck Joint Venture of the North American Waterfowl Management Plan, to develop statistically valid surveys for breeding populations and of reproduction rates for important areas in eastern Canada.

A final area suggested by Blandin (1982) was effort devoted to understanding interactions between black ducks and mallards. Work by Ankney et al. (1986) suggested that black ducks and mallards are genetically very close. However, Barnes (1988) identified differences in growth rates between mallards and black ducks, and Dennis et al. (1984) found lower recruitment rates for black ducks, suggesting evolved differences in life history patterns for the two taxa (see related discussion in Conroy and Krementz 1990:510). Analysis of population data by Ankney et al. (1987, 1989) suggested that decreases in breeding black duck populations were attributable to concurrent increases in mallard numbers, but see Conroy et al. (1989a) for a different interpretation. Regardless of the various conflicting interpretations about the taxonomic status of black ducks, and the relative importance of genetic swamping versus factors such as harvest and habitat loss, mallards will remain a topic of concern to black duck managers (e.g. Heusmann 1988; Seymour 1990).

Michael J. Conroy
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The following is a list of recent *Fish and Wildlife Research* publications.

1. Life History and Status of the Endangered Cui-ui of Pyramid Lake, Nevada, by G. Gary Scoppettone, Mark Coleman, and Gary A. Wedemeyer. 1986. 23 pp.
2. Spread, Impact, and Control of Purple Loosestrife (*Lythrum salicaria*) in North American Wetlands, by Daniel Q. Thompson, Ronald L. Stuckey, and Edith B. Thompson. 1987. 55 pp.
3. Taxonomy, Life History, and Ecology of a Mountain Mahogany Defoliator, *Stamnodes animata* (Pearsall), in Nevada, by Malcolm M. Furniss, Douglass C. Ferguson, Kenneth W. Voget, J. Wayne Burkhardt, Arthur R. Tiedemann, and John L. Oldemeyer. 1988. 26 pp.
4. Demographic Characteristics of a Maine Woodcock Population and Effects of Habitat Management, by Thomas J. Dwyer, Greg F. Sepik, Eric L. Derleth, and Daniel G. McAuley. 1988. 29 pp.
5. Premigrational Movements and Behavior of Young Mallards and Wood Ducks in North-central Minnesota, by Ronald E. Kirby, Lewis M. Cowardin, and John R. Tester. 1989. 25 pp.
6. Water and Habitat Dynamics of the Mingo Swamp in Southeastern Missouri, by Mickey E. Heitmeyer, Leigh H. Fredrickson, and Gary F. Krause. 1989. 26 pp.
7. Chironomidae of the Southeastern United States: A Checklist of Species and Notes on Biology, Distribution, and Habitat, by Patrick L. Hudson, David R. Lenate, Broughton A. Caldwell, and David Smith. 1990. 46 pp.
8. Forest Bird Habitat Suitability Models and the Development of Habitat Models, by Beatrice Van Horne and John A. Wiens. 1991. 29 pp.
9. Use of Wetland Habitats by Selected Nongame Water Birds in Maine, by James P. Gibbs, Jerry P. Longcore, Daniel G. McAuley, and James K. Ringelman. 1991. 57 pp.
10. Wigeongrass (*Ruppia maritima* L.): A Literature Review, by Harold A. Kantrud. 1991. 58 pp.

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